SURVEYS OF THE BEVERLY CARIBOU CALVING GROUNDS

1957 - 1994

Northwest Territories Resources, Wildlife & Economic Development

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1957 - 1994

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ABSTRACT

The Beverly caribou herd's calving grounds have been delineated in 23 years between 1957 and 1994 by the Canadian Wildlife Service (1957-1965) and the Department of Resources, Wildlife and Economic Development (1971-1994) and during monitoring (1978-1990) for the Caribou Protection Measures. A composite map was created by overlaying all calving grounds for the 23 years surveyed. Survey design, criteria for defining the calving ground, timing and coverage of surveys, and weather conditions have varied from year to year.

From 1957 to 1974, there was a high degree of overlap of areas used for calving. In 6 of the 8 years surveyed, the calving grounds were split from east to west by Beverly and Aberdeen Lakes with a large proportion of non-breeding animals in the southern area. From 1978 to 1994, there was also a high degree of overlap of areas used for calving. In these years, the calving grounds were northwest of areas previously used. In 1957 and 1958, several thousand cows calved west of the main herds.

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INTRODUCTION

Barren-ground caribou (*Rangifer tarandus groenlandicus)* annually return to calve on an area that largely overlaps with the areas used in previous years (Fleck and Gunn 1982). From a sample of cows collared in the Keewatin Region of the Northwest Territories, Heard and Stenhouse (1992) found that 85% returned to their previous calving location. The Department of Resources, Wildlife and Economic Development (RWED) defines ***traditional calving grounds*** as the areas known to be used for calving over many years by caribou from a particular herd, which includes all known annual calving grounds for that herd. The ***annual calving ground*** is the area known to be used for calving in one year by caribou from a particular herd using the best data available on the distribution of calving caribou.

The Beverly herd's traditional calving grounds lie across the eastern Thelon Game Sanctuary and stretch northeast beyond the sanctuary between Aberdeen Lake and Garry Lake (Fig. 1). Concerns over the effects of mineral exploration on barren-ground caribou in the area near Baker Lake in the 1960s and 1970s led the Department of Indian Affairs and Northern Development (DIAND), now Indian and Northern Affairs Canada, to implement the Caribou Protection Measures in 1978. Under the Caribou Protection Measures, special land management zones were established over the "critical-use areas" of both the Beverly and Qamanirjuaq caribou herds. Conditions were applied to new land

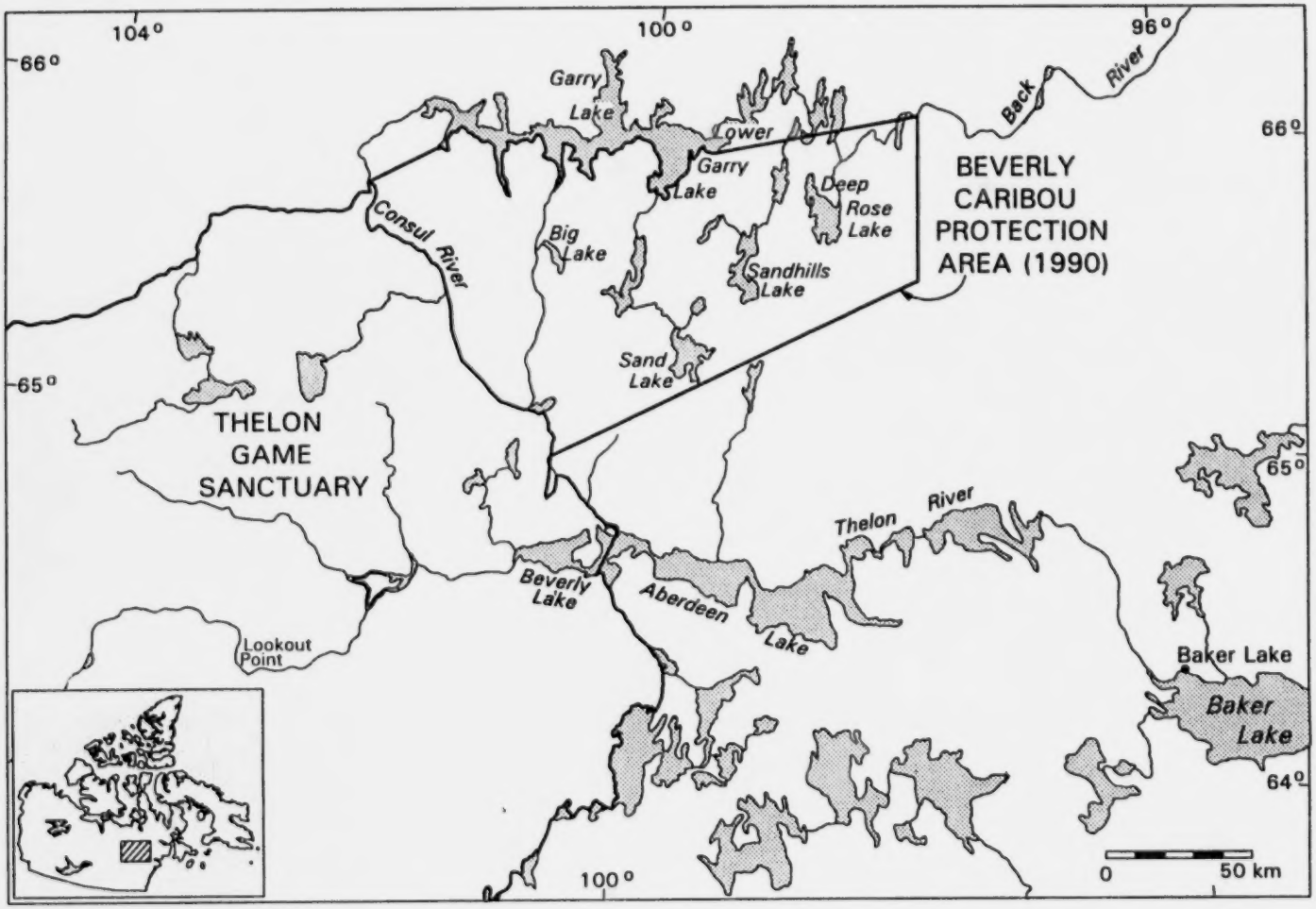

Figure 1. Study area.

use permits and a caribou monitoring program was introduced to ensure the effectiveness of these zones and conditions (Darby 1978, Mychasiw 1984). One of the objectives of this program was to "monitor and map the movements and activities of the Beverly and Kaminuriak[1] caribou herds during spring migration, the calving period and post-calving period" (Darby 1978:16). In 1978, DIAND in conjunction with the Canadian Wildlife Service (CWS), Northwest Territories Fish and Wildlife Service (now RWED[2]) and representatives from Baker Lake (in Ottawa) compiled a Caribou Protection Map, expanding on the "critical-use areas" of both the Beverly and Qamanirjuaq caribou herds identified by Interdisciplinary Systems Ltd. (1978) (Darby 1978). Known water crossings and the "primary calving area" and "primary post-calving area" of each herd, were identified on the 1978 Caribou Protection Map. Terms and conditions of the Caribou Protection Measures were reviewed in November of each year to recommend changes for the subsequent operating season (Mychasiw 1984). In 1979, the areas were revised to form a "traditional calving and post-calving area" and a "potential calving and post-calving area". In 1980, the "potential calving and post-calving area" was deleted and a general provision was applied that would suspend activity in any area occupied by cows and calves outside protection area boundaries (Mychasiw 1984). The area remaining was referred

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[1] now Qamanirjuaq

[2] The Northwest Territories Fish and Wildlife Service was the precursor to the Department of Renewable Resources which, since September 1996, has become part of the new Department of Resources, Wildlife and Economic Development.

to as the Caribou Protection Area. Activity was prohibited in protection areas from 15 May to 31 July. In 1983, the critical period was shortened to between 15 May and 15 July and has remained unchanged. The caribou monitoring program was discontinued in 1991, although the Caribou Protection Measures are still applied to permits being issued in the area.

The mining and industrial activities and our on-going requirements for efficient and economic survey designs indicate a need to be able to predict where caribou will calve. The first step is to map the boundaries of previous calving grounds to provide a measure of consistency of the likelihood that caribou will use those areas in the future.

Calving grounds are mapped during aerial surveys used to estimate caribou numbers. The CWS and RWED surveyed the Beverly herd's calving grounds 16 times between 1957 and 1994. Under the caribou monitoring program in 1978 and 1979, calving ground surveys were extensive, but from "1980 to 1982, only land use sites were monitored to verify whether or not caribou were in the area" (Mychasiw 1984:iii). Monitoring of land use sites continued until 1990. The calving grounds were mapped during these flights for the caribou monitoring program only in years when RWED did not complete a calving ground survey.

Our objectives in this report were: 1) to map the Beverly caribou herd's traditional calving grounds from the 1957-1994 surveys, 2) to collect flight lines and survey strata for each annual calving ground survey into one report and

3) to determine how frequently the Caribou Protection Area covered the annual calving grounds.

METHODS

The CWS documented caribou calving distribution in 6 years from 1957-1965 (1957, 1958, 1959, 1960, 1962, 1965). RWED surveyed the Beverly herd's calving grounds 10 times between 1971 and 1994 (1971, 1974, 1978, 1980, 1982, 1984, 1987, 1988, 1993, 1994). In 7 years between 1978 and 1990 when RWED calving ground surveys were not conducted, the calving grounds were delineated during the caribou monitoring program (1979, 1981, 1983, 1985, 1986, 1989, 1990). A composite map was prepared by overlaying the calving areas delimited in each survey during unsystematic and systematic reconnaissance flights.

Methods used in surveys by CWS were not detailed in the reports (1959, 1960) or reports were not available (1957, 1958; 1962, 1965). In most years, it appeared that reconnaissance surveys were used to locate the calving herd and record their movement to the calving area. Aerial counts were conducted to document the rate of calving and census the herd. Extensive ground segregations were used to determine band composition (McEwen 1959, McEwen 1960).

Each calving ground survey conducted by RWED started with an unsystematic search of the calving grounds to find caribou. This was termed the unsystematic or spaghetti reconnaissance. After the unsystematic reconnaissance, a transect survey was flown with transects systematically

spaced at equal intervals and these transects extended until no more cows were observed. In 1971 and 1974, the area covered by the transects and within the caribou distribution was divided into equal-area blocks. Randomly selected blocks were searched and caribou counted. In subsequent years, these random block surveys were not used. An additional strip survey was conducted in 1974 covering the same area as the block survey.

Stratification was part of the evolving design for calving ground surveys. It was added in 1978 to increase precision by adjusting survey intensity proportional to caribou density. The strata were blocks of similar caribou densities (low, medium, high) determined from the systematic reconnaissance which, before stratification, was referred to as the "transect survey". Evenly-spaced transects covered the area where caribou were seen during the spaghetti reconnaissance. Densities were estimated for 10-km segments along the transects and then areas with similar densities were grouped together to form strata. Each stratum was then surveyed using the appropriate number of systematic transects calculated according to a procedure detailed by Heard (1987) which gave the optimum coverage for each stratum depending on caribou density and the amount of flight time available.

In 1982, and for subsequent years, high altitude (600 m) aerial photography added another phase to the survey design. A photographic survey aircraft reflew the strata to photograph the caribou. In the first year, the photographic strata were delimited by grouping similar densities along 6.4-km (4-mi) segments

of the transects flown in each stratum of the stratified transect survey. After 1982, the same strata boundaries drawn for the stratified transect survey were used for the photographic survey. As was mentioned above, these were based on groups of similar caribou densities determined during the systematic reconnaissance. In 1988, the stratified transect survey was dropped and only a photographic estimate was obtained.

Between 1978 and 1984, ground composition counts were conducted to determine the proportion of breeding females on the calving grounds. After 1987, ground composition counts were replaced with systematic classification flights to sample the age, sex and reproductive condition of caribou in each stratum (Williams 1995).

During years when no RWED survey was conducted, the calving grounds were delineated during 1 or 2 reconnaissance flights conducted for the caribou monitoring program.

In this report, the survey design has been described in only enough detail to explain the different mapped flight lines for each survey. The rationale for the design and other details are in the cited reports.

Figures

From 1978-1994, original spaghetti reconnaissance flight lines were recorded on 1:500 000 scale maps. Flight lines for the systematic reconnaissance, stratified transect, photographic, and composition surveys when

completed were recorded on 1:250 000 scale maps. Flight lines were transferred to basemaps in *Freelance Graphics*[3] from original maps for the 8 years of RWED calving ground surveys from 1978 to 1994 and, in non-survey years, for the 7 years of monitoring flights from 1978 to 1990. (Basemaps were imported into *Freelance Graphics* from *QUIKMap*[4]). All lines were drawn by hand. For the earlier surveys from 1957 to 1974, all information was taken from unpublished reports and transferred to maps in the same manner as stated above.

Strata density classifications (high, medium, low) were taken from unpublished reports, survey and file notes, or original survey maps.

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[3] *Freelance Graphics* is a graphics software package from Lotus Development Corporation.

[4] *QUIKMap* is a software package used to put geo-referenced information on maps. It is produced by ESL Environmental Services Limited, Sydney, BC.

RESULTS AND DISCUSSION

The Beverly herd's traditional calving grounds (Fig. 2) are mapped from the location of cows and yearlings until 1974 and from the location of parturient cows and cows with calves from 1978 to the present. There is a high degree of overlap for the surveys from 1978 to 1994. The highest frequency of overlap is concentrated between Sand and Garry Lakes, and Deep Rose Lake and the Consul River (Fig 1.) where areas have been used for as many as 14 to 15 years out of the 23 years in which the calving grounds were delineated (Fig. 3). Mapping just the areas designated as high density from 1978 to 1994 (Fig. 4) shows a clustering in the same area. A table with the associated caribou densities is in Appendix A.

There is also a high degree of overlap in calving grounds delineated during surveys prior to 1978. These annual calving grounds were split by Beverly Lake and the Thelon River valley in at least 6 of the 8 years surveyed from 1957 to 1974 (Figs. 5 - 16)[5]. In 1957, Kelsall did not fly north of Beverly Lake (Fig. 5), but tracks indicated that some caribou did travel to the north side of the lake (Kelsall 1957, Fleck and Gunn 1982). He also reported several thousand cows calving approximately 200 km west and 300 km southwest of the main herds in 1957 and 1958, respectively, and speculated that they were "almost certainly diverted, or retarded, during spring migration due to unusual snow conditions"

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[5] Figures 5 to 68 appear together in the main body of this report beginning on page 29.

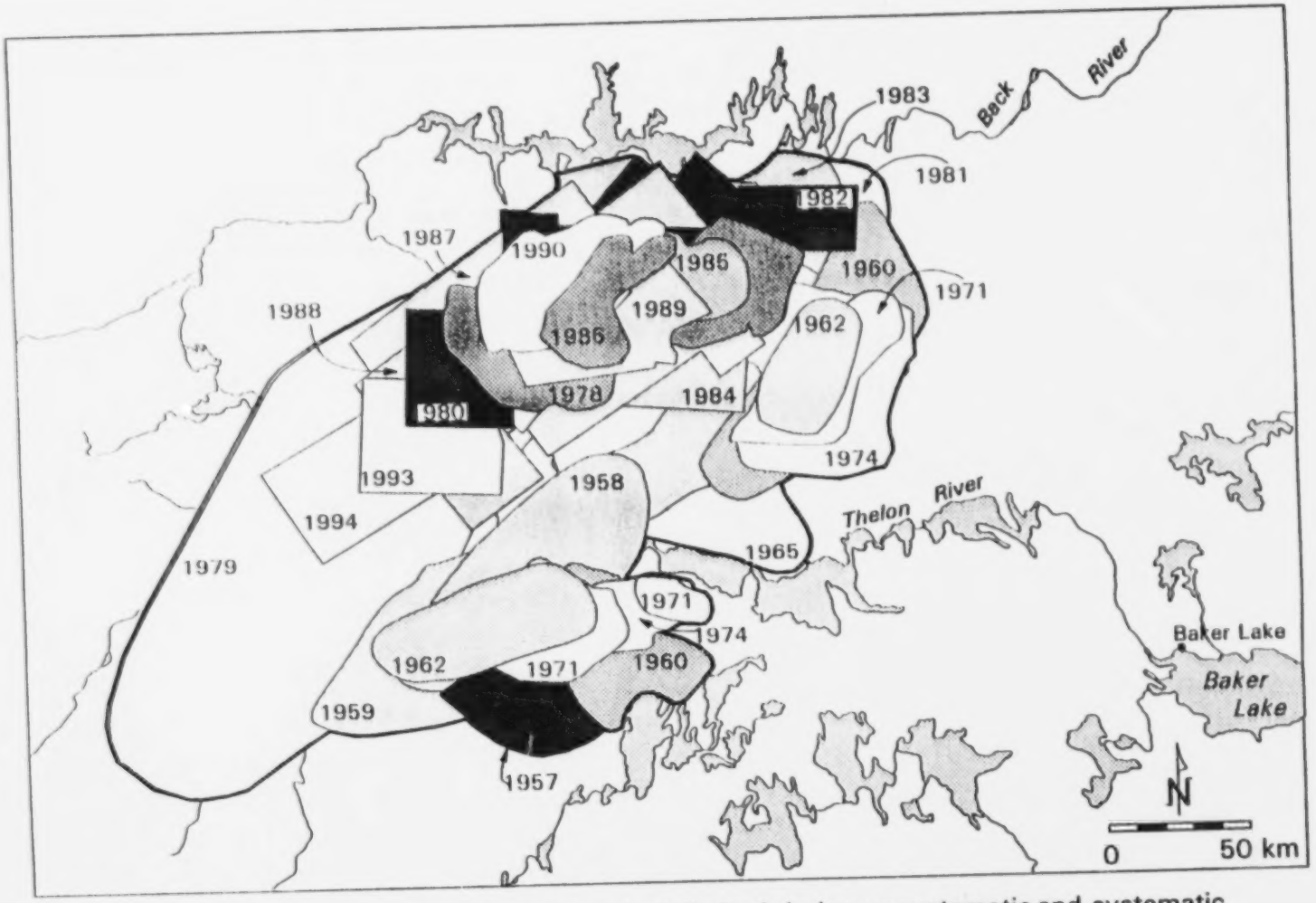

Figure 2. Superimposed annual calving grounds delimited during unsystematic and systematic reconnaissance surveys on the Beverly calving grounds, 1957-1994

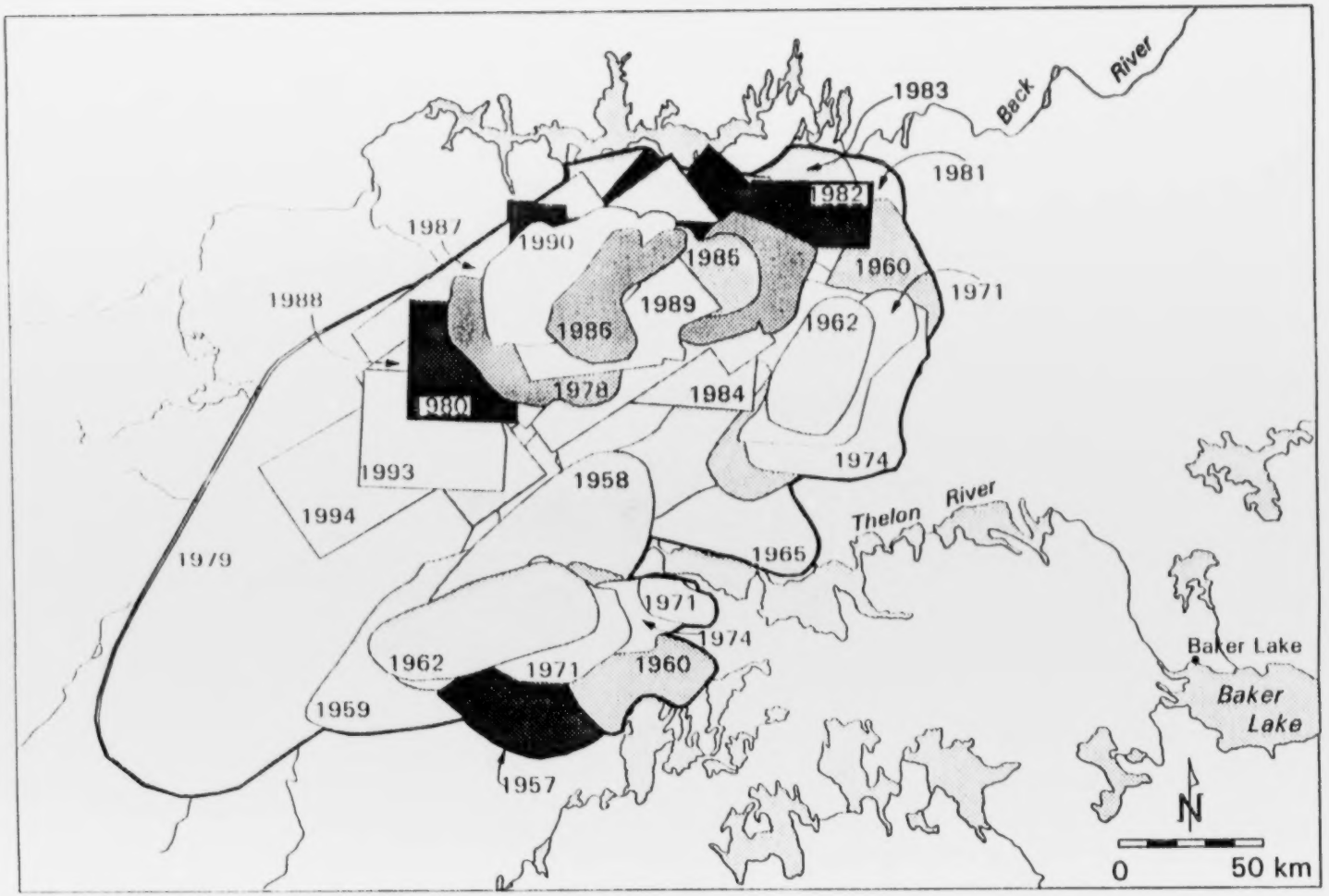

Figure 2. Superimposed annual calving grounds delimited during unsystematic and systematic reconnaissance surveys on the Beverly calving grounds, 1957-1994

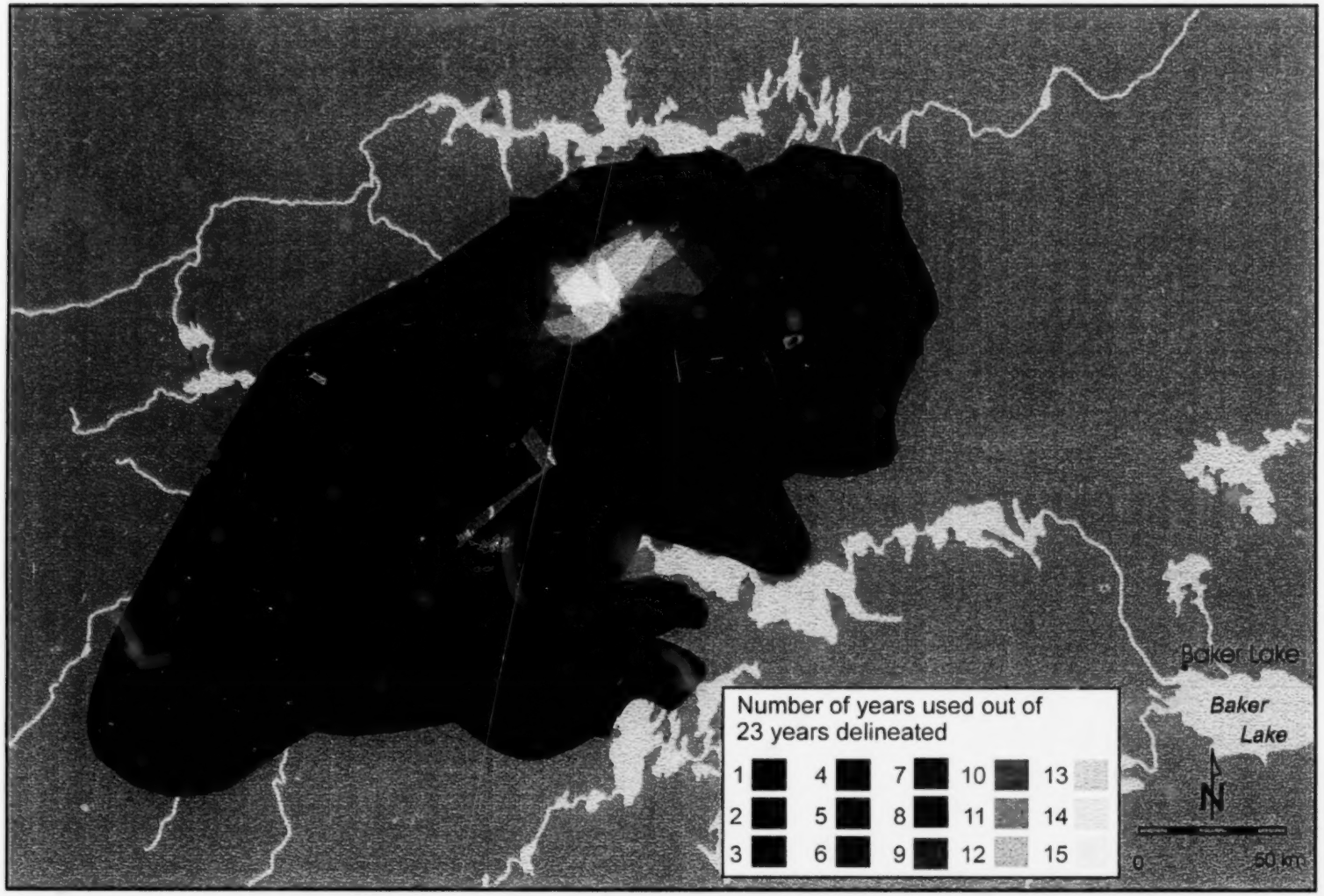

Figure 3. Frequency of use on the Beverly caribou calving grounds, 1957-1994

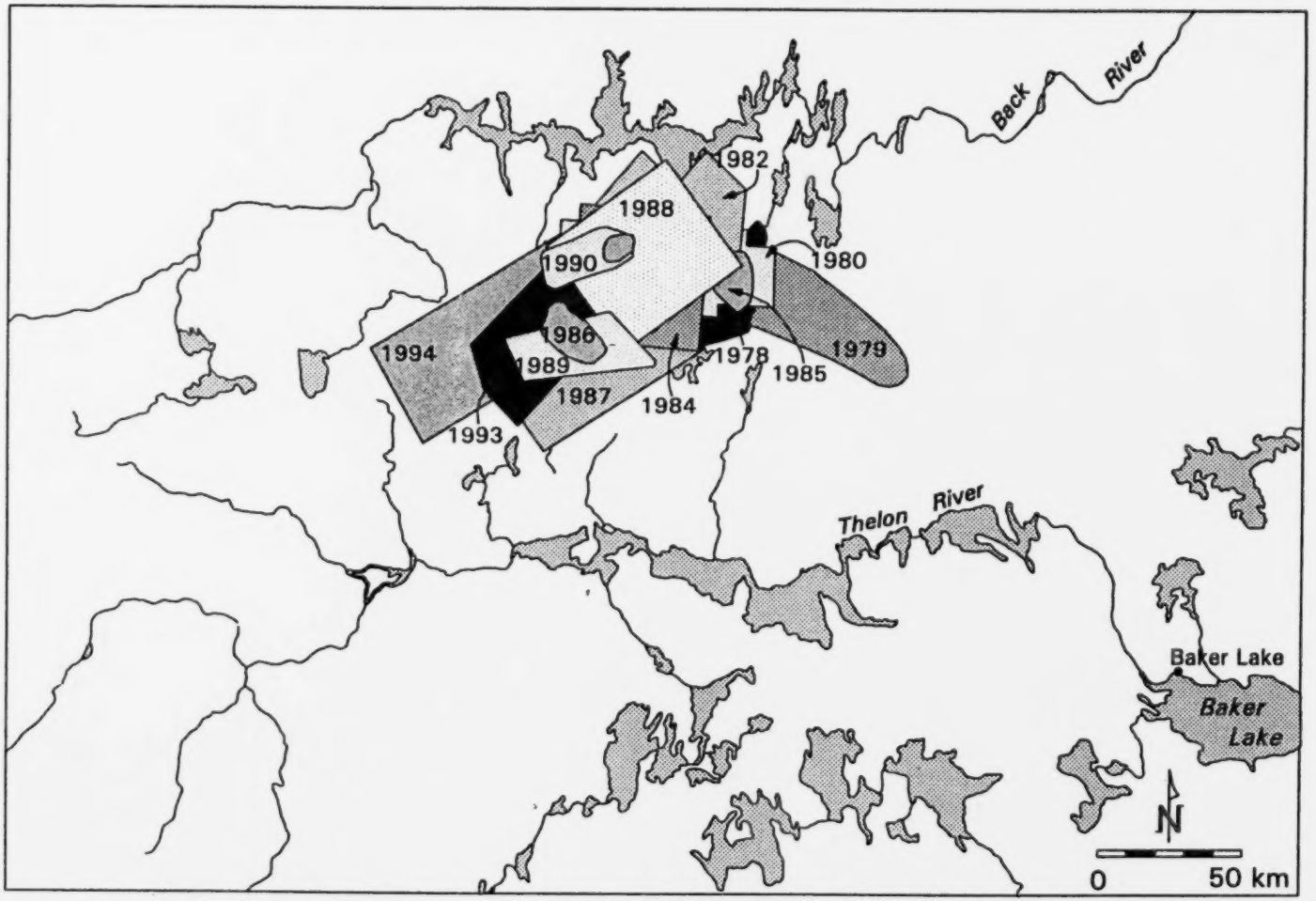

Figure 4. High density strata from the 1978-1994 surveys on the Beverly calving grounds

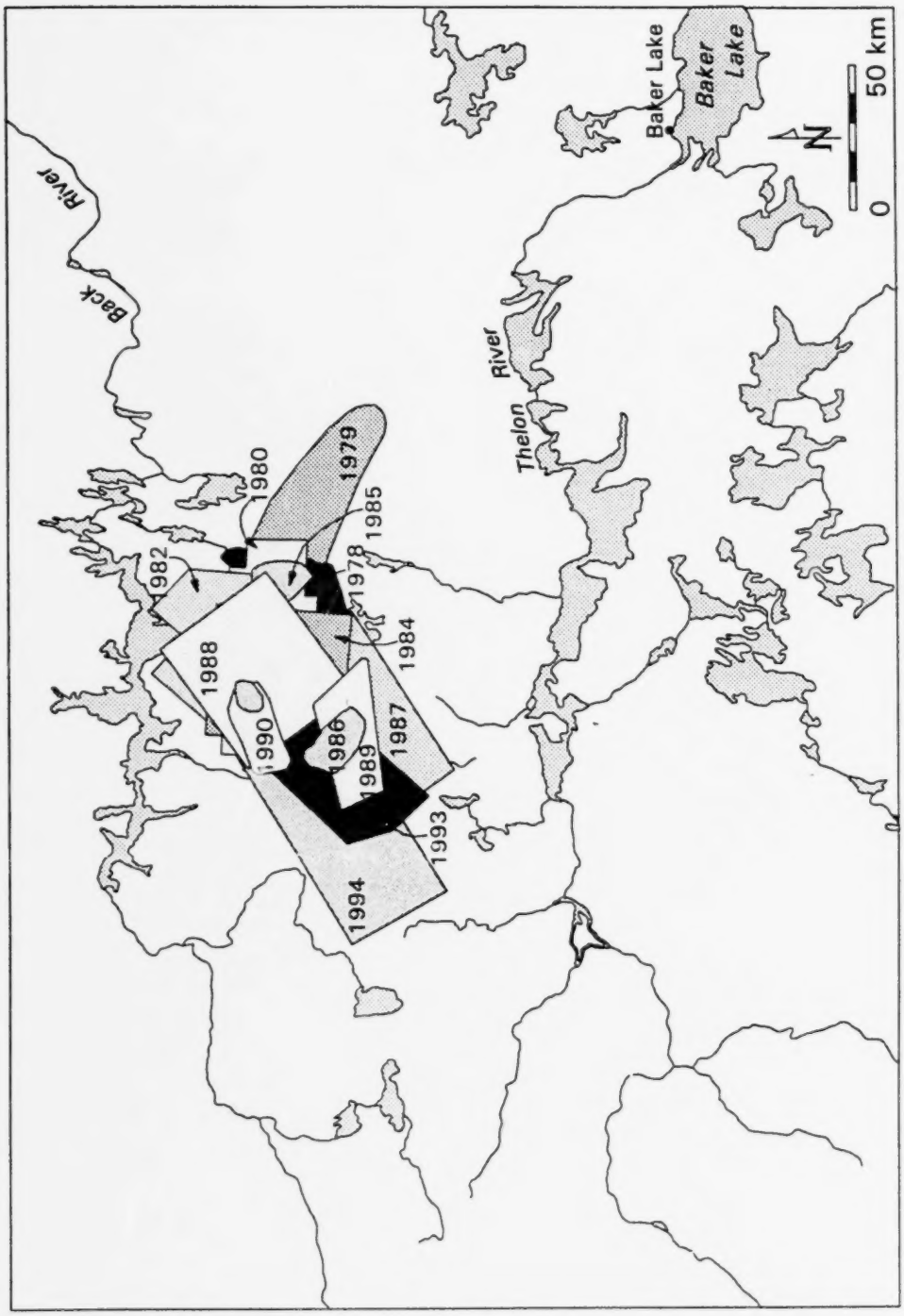

Figure 4. High density strata from the 1978-1994 surveys on the Beverly calving grounds

(Kelsall 1968:178). In years when calving was reported on both sides of Beverly Lake, caribou on the calving grounds south of the lake appeared to be predominantly non-breeding animals (McEwen 1959, McEwen 1960, Moshenko 1974, Fleck and Gunn 1982). Kelsall (1968) reported that calving took place on high areas both north and south of Beverly Lake. In 1974, reconnaissance flights (Fig. 13) did not cover the northeast part of the traditional calving grounds where calving has occurred since 1978.

In 1978, the area around Beverly Lake was searched during reconnaissance flights (Fig. 17), but no calving cows were found (Heard and Decker 1980). This was the first year, since 1957, that the calving ground was not located near Beverly Lake, but further north between Deep Rose Lake and the Consul River (Figs. 18 - 20). Based on the results of the systematic reconnaissance, the calving grounds were divided into four strata (Fig. 19). The distribution of caribou changed after the reconnaissance survey and, during the stratified transect survey, no calves were observed in stratum 2 which was, therefore, not included in calculations of the population estimate (Heard and Decker 1980).

To delineate the calving grounds in 1979, the caribou monitor flew from 4-9 June in the vicinity of Beverly Lake and also north in the area where caribou calved in 1978 (RWED files) (Figs. 21 and 22).

From 1980 to 1982, reconnaissance flights covered all previous calving areas (Figs. 23 - 34). No calving caribou were found near Beverly Lake (Gunn and Decker 1982, Clement 1982, Stephenson et. al. 1984).

In 1983, the caribou monitor conducted flights to delineate the Beverly calving grounds on 2, 7 and 17 June (Bradley and Gates 1984). Flight maps were not available. The annual calving ground (Fig. 35) was located in an area very similar to the 1981 and 1982 annual calving grounds. Bradley and Gates (1984:8) noted that the "arrival of caribou on the calving ground in 1983 was later than in the previous 2 years" and that on 17 June, "caribou seen along the western edge of the calving ground were mostly yearlings and other non-breeders."

Unsystematic reconnaissance flight maps were not available for the 1984 survey, however, Gates (1984:2) reported that "preliminary reconnaissance was carried out on 5 and 6 June to roughly locate the area containing the calving ground population and to check the outlying area known to have been used historically at calving time." In 1984, cows again calved mainly in an area between Sand and Garry Lakes (Figs. 36 - 38).

In 1985, during a caribou monitor flight to document late spring migration on 22 May, Duquette (1985:10) noted that " the majority of cows and yearlings were densely concentrated along the northern boundary of the Caribou Protection Area along the south shore of Garry Lake and Lower Garry Lake." This appears to be the only flight that covers the area near Beverly Lake.

Further reconnaissance flights were conducted on 31 May and 8 June to determine the distribution of calving caribou (Figs. 39 and 40).

In 1986, during a caribou monitor flight on 16 May (pre-calving) which passed near Beverly Lake, Liepins (1986:11) observed that "caribou were widely dispersed across the Protection Area." One reconnaissance flight was conducted on 10 June to determine the distribution of calving caribou (Figs. 41 and 42).

RWED conducted calving ground surveys in 1987 and 1988. No calving caribou were found in traditional calving areas near Beverly Lake when searched and the annual calving grounds were again located where they have been since 1978, but extended about 50 km to the southwest (Figs. 43 - 52).

In 1989 and 1990, one reconnaissance flight each year on 10 June was used to delineate the annual calving grounds (Figs. 53 - 56). In 1989, Chalmers (1989:14) reported that "based on the small number of calves seen, it can be assumed that calving was just beginning. Numerous caribou were still migrating toward the core calving area." By 10 June 1990, Gauthier and Mulders (1990:16) observed that "approximately 50% of females were accompanied by calves". They also noted that "a moderate density area spreading southwestwards from the high density area suggests that the calving area may have extended further southwest towards the Protection Area boundary. However, this distribution could not be confirmed by this flight."

Reconnaissance flights during the two most recent Beverly calving ground surveys conducted in 1993 and 1994, covered the entire traditional calving grounds. In both years, the annual calving grounds and the high density areas (Fig. 3) were southwest of areas used for calving since 1978 (Figs. 57 - 66).

The composite map (Fig. 2) reveals that within the Beverly herd's traditional calving grounds, calving took place mainly in eastern and southeastern areas during the 1960s and early 1970s. In the late 1970s and throughout the 1980s, calving occurred in areas slightly north and west of those used in previous years. Recently, in the 1990s, the annual calving grounds appear to have shifted southwest of calving areas used in the 1980s. Experience with the Bathurst herd's calving grounds (Sutherland and Gunn 1996) over four decades also reveals a shift in the location of the annual calving grounds. However, four decades is too brief a time period to discern if the shift is a rotation onto areas previously used. The ***traditional calving grounds*** comprise the areas known to be used for calving over *many* years and 23 surveys during 4 decades may not be an adequate sample.

The high degree of overlap between annual calving grounds indicates that the location is relatively predictable over both the short term and the long term, but we caution that the mapped (Fig. 2) traditional calving grounds have limitations in predicting the location for future annual calving grounds. As was mentioned above, the sample period (1957-1994) is too short to provide a complete picture of all calving ground locations or trends in location from year to

year. A survey of Inuit traditional knowledge on calving distribution may extend the sample period. In addition, the calving grounds mapped from caribou monitoring flights only apply to the distribution at or close to the calving peak for 1 to 3 days when each annual calving ground was surveyed. Calving occurs each year on the Beverly calving grounds from around 25 May to 25 June during the ***calving period*** which is the time between the earliest and latest births (Gunn 1984). Within this period, there is a 5-day interval when most calves are born (Fleck and Gunn 1982). In the Beverly caribou herd, the peak of calving, when half of the parturient cows have calved (Williams 1994), is usually during the 2nd week of June (Kelsall 1968). The mean dates of the peak calving interval fall between 7 and 11 June (Fig 67)[6]. Therefore, the mapped annual calving grounds in some years are only a snapshot of the calving distribution during a survey that lasts up to 3 days. The disfribution immediately before or after peak calving is not included.

The confidence with which we have mapped the Beverly herd's calving grounds is also influenced by two quite separate sources of uncertainty - technical and environmental. Listed here are five technical uncertainties: changes in survey design, changes in timing, weather, adequacy of coverage, and missing data.

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[6] Peak calving dates were taken from unpublished and draft reports when available. In the remaining years, peak calving dates were approximated from raw data (Appendix B).

1. Survey design has evolved over the years (Table 1) as well as the criteria used for delineating calving grounds (Table 2). In 1959 and 1960, the location of the calving ground was determined on the basis of cow and yearling locations (McEwen 1959, McEwen 1960). In 1971 and 1974, the boundary was drawn when adult cows were no longer seen and the composition was mainly made up of yearlings (Rippin 1971, Baker 1974). From 1978 on, the calving ground was defined as the area occupied by parturient cows and cows with calves (Heard and Decker 1980).

2. Timing of surveys has varied relative to peak calving dates (Fig. 67). Peak calving is important to survey timing because the optimum time for surveying is during the peak when caribou are relatively dispersed (as compared to clumped) and are not extensively moving. It is also important for mapping and defining calving boundaries in that before the peak, cows may still be arriving at the calving ground and their distribution may thus be more extensive. After the peak and once the calves are a few days old, the cows start to move together into larger groups which can travel swiftly. Those movements before and after the peak mean that the mapped boundaries can and do change rapidly.

3. Weather conditions at survey time may have had an effect. Breaks or delays in surveying are most often the result of bad weather conditions preventing flying.

4. Coverage of the entire traditional calving grounds in some years may not have been adequate and areas with calving caribou may have been missed.

Table 1. Summary of survey dates and details, Beverly calving grounds, 1960-1994.[a]

Year	Unsystematic Reconnaissance	Systematic Reconnaissance	No. of strata	Random block survey	Stratified transect survey	Photographic survey	Composition survey	Source/ Comments
1960	7 June (delineation) (N)	10, 11 June (census) (N) 12 June (S)	--	--	--	--	29 May-3 June, 7, 10 June (ground survey)	McEwen 1960; aerial samples of ratio of calves to total for progression of calving, to 12 June.
1971	3-5 June	6 June (S) 8 June (N)	--	7 June (S) 9 June (N)	--	--	6-15 June (ground survey) 6 June	Rippin 1971 Moshenko 1974; also completed a strip survey on 6-7 June
1974	1,3 June	2 June (N) 3-4 June (S)	--	3-6 June (N) 5 June (S)	--	--		
1978	26 May-8 June	9 June	4	--	10-11 June	--	30 June-2 July (ground survey)	Heard and Decker 1980
1980	1-3 June	5 June	2	--	6,8 June	--	13-14 June (ground survey)	Gunn and Decker 1982
1982	5 June	8-9 June	3	--	11-12 June	12-13 June	12-16 June (ground survey)	Stephenson et al. 1984
1984	5-6 June	6 June	5	--	7-8 June	12-13 June	9-12 June (ground survey)	Gates 1984
1987	2-3 June	7 June	4	--	8-9 June	--	9-10 June	Heard et al. 1990
1988	2,4 June	5-6 June	3	--	--	8, 9, 12 June	8, 9,11,14 June	Heard and Jackson 1990
1993	5-6 June	6 June	2	--	--	11-12 June	11-16 June	Williams 1995
1994	2-3 June	4-5 June	2	--	--	7-8 June	9-13 June	Williams 1995

[a] CWS conducted the surveys in 1959 and 1960 and the remainder were conducted by RWED. CWS surveys for which no information was available (1957, 1958, 1959, 1962, 1965) have not been included in the table.

Table 2. Size of the annual calving grounds (km^2) of the Beverly barren-ground caribou herd, 1959-1994[a].

Year	Survey used to delineate calving grounds	Criteria used to delineate calving grounds	Area (km^2)	Source/Comments
1959	unsystematic reconnaissance	location of cows, including yearlings on periphery	2300	McEwen 1959
1960	unsystematic reconnaissance	location of cows, including yearlings on periphery	2048 (N) 3840 (S)	More non-calving animals in the South (McEwen 1960).
1971	systematic reconnaissance (S) unsystematic reconnaissance (N)	location of adult cows; boundary drawn where composition of caribou becomes primarily yearlings	3364	Rippin 1971
1974	systematic reconnaissance	boundary drawn where composition of caribou becomes primarily yearlings (Baker 1974)	4219	Moshenko 1974
1978	systematic reconnaissance	location of parturient cows	4533	Heard and Decker 1980
1979[b]	unsystematic and systematic reconnaissance	location of parturient cows	16 000	Darby 1979
1980	systematic reconnaissance	location of parturient cows	5288	Gunn and Decker 1982
1981[b]	unsystematic reconnaissance	location of parturient cows	--	Clement 1982
1982	systematic reconnaissance	location of parturient cows	4219	Stephenson et al. 1984
1983[b]	unsystematic reconnaissance	location of parturient cows	--	Bradley and Gates 1984
1984	systematic reconnaissance	location of parturient cows	5889	Gates 1984
1985[b]	unsystematic reconnaissance	location of parturient cows	--	Similar to 1980 (Duquette 1985).
1986[b]	unsystematic reconnaissance	location of parturient cows	--	Part of traditional calving ground between Deep Rose and Sand Lakes was not surveyed (Liepins 1986)
1987	systematic reconnaissance (N,W) unsystematic reconnaissance (S,E)	location of parturient cows	7828	Heard et al. 1990
1988	systematic reconnaissance	location of parturient cows	6183	Heard and Jackson 1990
1989[b]	unsystematic reconnaissance	location of parturient cows	2040	Chalmers 1989
1990[b]	unsystematic reconnaissance	location of parturient cows	2055	Gauthier and Mulders 1990
1993	systematic reconnaissance	location of parturient cows	3200	Williams 1995
1994	systematic reconnaissance	location of parturient cows	5011 [3300]	This is the area of the strata delineated from results of the systematic reconnaissance (RWED files). The area in brackets was used to calculate the population estimate (Williams 1995)
TOTAL			40 000	Estimate calculated in *Freelance* (Fig. 2)

[a] CWS surveys for which no information was available (1957, 1958, 1962, 1965) have not been included in the table.

[b] Data from the Caribou Monitoring Program.

Most of the unsystematic reconnaissance flights during RWED's calving ground surveys to estimate caribou numbers covered the entire traditional calving grounds. Flights conducted during the caribou monitoring program, especially after 1980, were not as extensive and calving areas may have been missed. One reported incidence was in 1986 when part of the traditional calving grounds between Deep Rose and Sand Lakes was not surveyed (Liepins 1986).

5. Flight lines may not have been recorded. If flight lines are missing, it is not known whether flights were conducted over a particular area and no caribou were found or whether the area was simply not surveyed. Flight lines for the 1957 to 1965 surveys conducted by CWS were not available or maps from reports could not be reproduced. Lines flown during the caribou monitoring program in 1983 and unsystematic reconnaissance and stratified transect survey flight lines for the 1984 RWED calving ground survey were not available.

The environmental uncertainties that are incorporated in the composite map are those ecological variables, unpredictable from year to year, that affect the caribou's distribution and behaviour. The most prominent is annual variations in weather. Snow depths and melt rate on the calving ground may influence the cows' distribution. If the caribou must trudge through deep, wet or crusted snow during spring migration, some cows may be delayed in reaching the calving grounds and the annual calving ground may be larger than usual. This was probably the case in 1979 (Fig. 22). Severe winter weather may influence the condition of cows over the winter. The timing of the calving peak is

affected by a variety of factors. For example, severe insect harassment over the summer may influence the condition of cows in the fall, delaying the onset of heat cycles and conception dates. If large numbers of cows do not conceive until the second or third heat cycles, the peak of calving will be delayed. Poor condition of cows in the fall may also retard fetal growth rates. Gestation may be prolonged (Bergerud 1975, Espmark 1980) and again, calving may peak later than normal (Gunn 1984). We are not yet at the stage where we can quantify the environmental effects. If they could be quantified, then the probability of predicting the location of the calving ground in any one year could be refined.

The degree of overlap between annual calving grounds partly reflects survey frequency - the more frequent the surveys, the greater the overlap. Overlap in the annual calving grounds is highest from 1978 to 1994, which to some extent may reflect the frequency of those surveys. In 16 years, 15 surveys were conducted at a mean frequency of 1 per year. In comparison, from 1957 to 1974, the survey frequency was a mean of 1 every 2.5 years for a total of 8 surveys in 17 years.

The degree of overlap may also be influenced by calving ground size (Table 2, and thus the caribou densities Appendix B). Variations in calving ground size are due to ecological factors, survey timing and how the boundary was determined, and may also reflect behavioural factors such as herd density. The size of the calving grounds has varied greatly between years. In 1986, the annual calving grounds covered the smallest area of approximately 1000 km^2

(Table 2), however, part of the traditional calving grounds between Deep Rose and Sand Lakes was not surveyed that year (Liepins 1986). In 1979, calving occurred over a much larger area than in other years (approximately 16 000 km^2). The large size of the 1979 calving grounds probably resulted from a delay in spring migration due to unfavourable weather conditions. Cows were calving when surveyed between 4 and 9 June, although many had not yet reached their known traditional calving grounds (Darby 1980). Excluding these two years, calving ground size ranged from about 2000 km^2 to 8000 km^2 between 1978 and 1994 (Table 2). The entire traditional calving grounds of the Beverly caribou herd cover approximately 40 000 km^2. The intuitive thought that the larger the population, the larger the calving ground appears too simple at the current range of population sizes. Calving ground size from 1971 to 1987 does not correlate with population size. The criteria for determining boundaries, which was different for surveys in 1971 and 1974, and the timing of surveys relative to the peak of calving are two additional factors that may affect calving ground size (Fig. 68).

Information from the calving ground surveys has also contributed, along with results of the caribou monitoring program, to evaluating Caribou Protection Area boundaries. Between 1978 and 1990, the boundaries of the Caribou Protection Area for the Beverly caribou herd were revised 6 times according to patterns of use over previous 5-year periods.[7] The annual calving grounds were

[7] Maps of the Beverly Protection Areas from 1978 to 1990 can be found in Appendix D.

located entirely within Caribou Protection Area boundaries (and the Thelon Game Sanctuary) in 6 of 13 years between 1978 and 1990 (Table 3). In 1994 and 1995, the annual calving grounds were within Protection Area boundaries, which have not be revised since the monitoring program ended after 1990. The degree to which the annual calving grounds were located outside the boundaries varied from 50% in 1978, the first year that the Caribou Protection Measures were implemented, to less than 5% in 1979, 1980, 1981 and 1987 (Table 3).

The shift or rotation of occupation within the traditional calving grounds raises questions whether caribou influence or change the area and those changes consequently reduce, at least for decades, its attractiveness to the caribou. One obvious feedback would be from foraging: Crête *et al* (1996) suggested that high caribou densities changed plant communities on the George River caribou herd's summer range. On the calving grounds, caribou use may alter lichen cover on the uplands causing rotational use.

Another possibility is whether preditors learn to converge on an area and that the caribou shift to reduce the exposure. Bergerud (1996) has convincingly argued for caribou's anti-preditor strategies as being one reason for caribou calving grounds being removed from the treeline. The mobility of predators and distances the caribou shift over a few years detract from predater avoidance as an explanation for a shift within traditional calving grounds.

Parasites are a less conspicious influence on caribou ecology than predators but that may be because we tend to ignore parasites or assume them

to be relatively benign. Parasites, specifically oestrid flies, influence caribou migration at least in Norway (Folstad *et al* 1991). Reindeer herds that migrated further between their summer ranges and calving grounds have lower densities of warble infestation compared to herds that summered on or near their calving grounds. To test the hypothesis, warble larvae on reindeer killed in the spring were counted and compared with the distance between the summer ranges and the calving grounds: the shorter the distance, the earlier the caribou arrived on their summer range and the more they were infested by warbles. Warble larvae are shed in Norway from April to June with a peak from 10 May to 10 June (Nilssen and Haugerud 1994). The warble flies deposit their eggs on the reindeer between about 10 July to 20 August depending on air temperatures.

Warbles usually more heavily infect caribou and reindeer bulls and calves than cows (Kelsall 1957, Folstad *et al* 1989). Cows may acquire immunity while bulls lose their immunity through the joint action of rutting stress and high levels of serum testosterone. The effect of differing distribution during early summer between bulls and cows has not been determined, but the bulls do follow after the cows and may pass through areas where the cows have shed warbles. This could be tested using information from satellite-tracked cows and counts of warble pupae. However, even if cows are calving remote from their summer ranges to avoid warbles (in parallel with avoiding wolf denning along the treeline), this does not explain shifts within the traditional calving grounds.

Shifts within the traditional calving grounds may be related to other parasites. Folstad *et al* (1991) commented that calving grounds "may develop into transmission foci for parasites, where females and their susceptible calves would experience intense parasitic transmission." The comment is based on the observation of a rise in larval output by abomasal nematodes when the host's pregnancy and lactation cause immunosuppression. Parasites such as *Ostertagia* spread through fecal contamination of forage. If the high densities on the calving grounds lead to build-up of parasites, then that could explain the decadal shift or rotation. However, there would have to be a feedback between the parasites and the caribou to trigger a behavioural shift in the caribou to start to abandon the area. At first sight, this seems unlikely but, given the intricacy of parasite-host relations, the apparent absence of a feedback may be due to the fact that we have not looked or known what to look for.

In conclusion, the emphasis in this report was compilation - to pull together the maps and dates from a disparate set of reports and field maps and to produce and justify a composite map of the Beverly herd's calving grounds. Factors influencing the confidence with which past calving grounds were mapped have also been discussed. We recognise that this report is but the first step and, in a future report, we will present an analysis of the Beverly herd's calving distribution. We will also follow-up examining the role of parasites and forage in the shifts of annual calving grounds within the traditional calving grounds.

Table 3. Summary of Caribou Protection Measures monitoring contributions, Beverly calving grounds, 1978-1990.

Year	Calving Ground Delineation Flight Dates	RWED Survey Year	Caribou Protection Area	Coverage	Source
1978	"During June through early August each herd was intensively surveyed every 2 to 2½ weeks in addition to irregular flights " (Darby 1978:19).	Y	DIAND certified the Caribou Protection Map which defined the critical areas (Darby 1978).	"In 1978 approximately 50% of the area where the Beverly herd calved was outside of the Primary Calving Area and not within the Thelon Game Sanctuary" (Darby 1978:62).	Darby 1978
1979	4-9 June	N	The 1979 Caribou Protection Map was revised to include the area to the NW where calving occurred in 1978 (Darby 1978) and areas where revised to form the "traditional calving and post-calving area" and the "potential calving and post-calving area".	Part of the calving grounds (<5%) were outside the "traditional calving and post-calving area" in the NW near and all were within the "potential calving and post-calving area".	Darby 1980
1980	11, 14 June (to monitor land use sites)	Y	The "potential calving and post-calving area" was deleted and the remaining area was referred to as the Caribou Protection Area.	Part of the calving grounds (<5%) were outside the Caribou Protection Area in the NW near Big Lake.	Cooper 1981
1981	3, 15 June	N	No change.	Part of the calving grounds were outside the Caribou Protection Area boundary in the NW near Big Lake (~15%) and N of Sandhills Lake (<5%).	Clement 1982
1982	--	Y	No change.	Part of the calving grounds (~25%) were outside the Caribou Protection Area boundary to the N from Big Lake to Deep Rose Lake.	Clement 1983
1983	2, 7, 17 June	N	The 1983 boundary was revised to include an area in the N and to exclude the area below Sand Lake.	Calving grounds were within Caribou Protection Area boundaries.	Bradley and Gates 1984
1984	19 June (post-calving)	Y	No change.	Areas of the calving grounds extended outside the Caribou Protection Area to both the N (~5%) and S (~10%).	Bradley 1985
1985	8 June	N	The 1985 boundary was revised to extend the northern boundary of the present Caribou Protection Area up to Garry Lakes and to exclude the SE corner.	Calving grounds were within Caribou Protection Area boundaries. (A large post-calving aggregation was found just outside the NW corner of the Caribou Protection Area.)	Duquette 1985
1986	10 June	N	The 1986 boundary was revised to include an area in the NW.	Calving grounds were within Caribou Protection Area boundaries.	Liepins 1986
1987	20 June (post-calving)	Y	No change.	Calving occurred outside the S boundary, W of Sand Lake in 1987 (<5%) as in 1984.	Ogilvie 1987
1988	--	Y	The 1988 boundary was revised to include an area to the SW where calving occurred in 1987 and 1984.	Calving grounds were within Caribou Protection Area boundaries.	Ogilvie 1989
1989	10 June	N	No change.	Calving grounds were within Caribou Protection Area boundaries.	Chalmers 1989
1990	10 June	N	No change.	Calving grounds were within Caribou Protection Area boundaries.	Gauthier and Mulders 1990

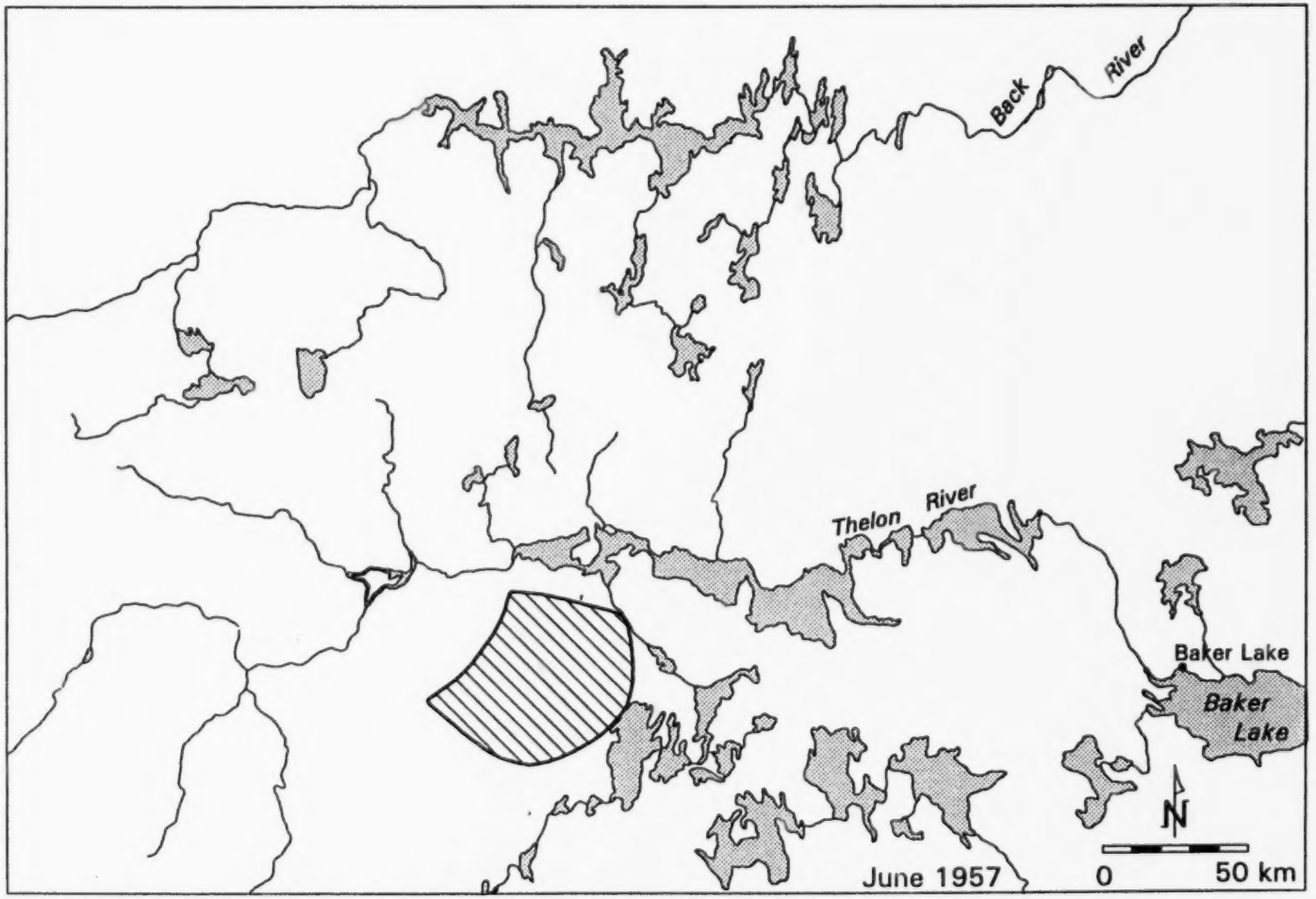

Figure 5. Beverly caribou calving distribution, June 1957 (Darby 1978, Fleck and Gunn 1982)

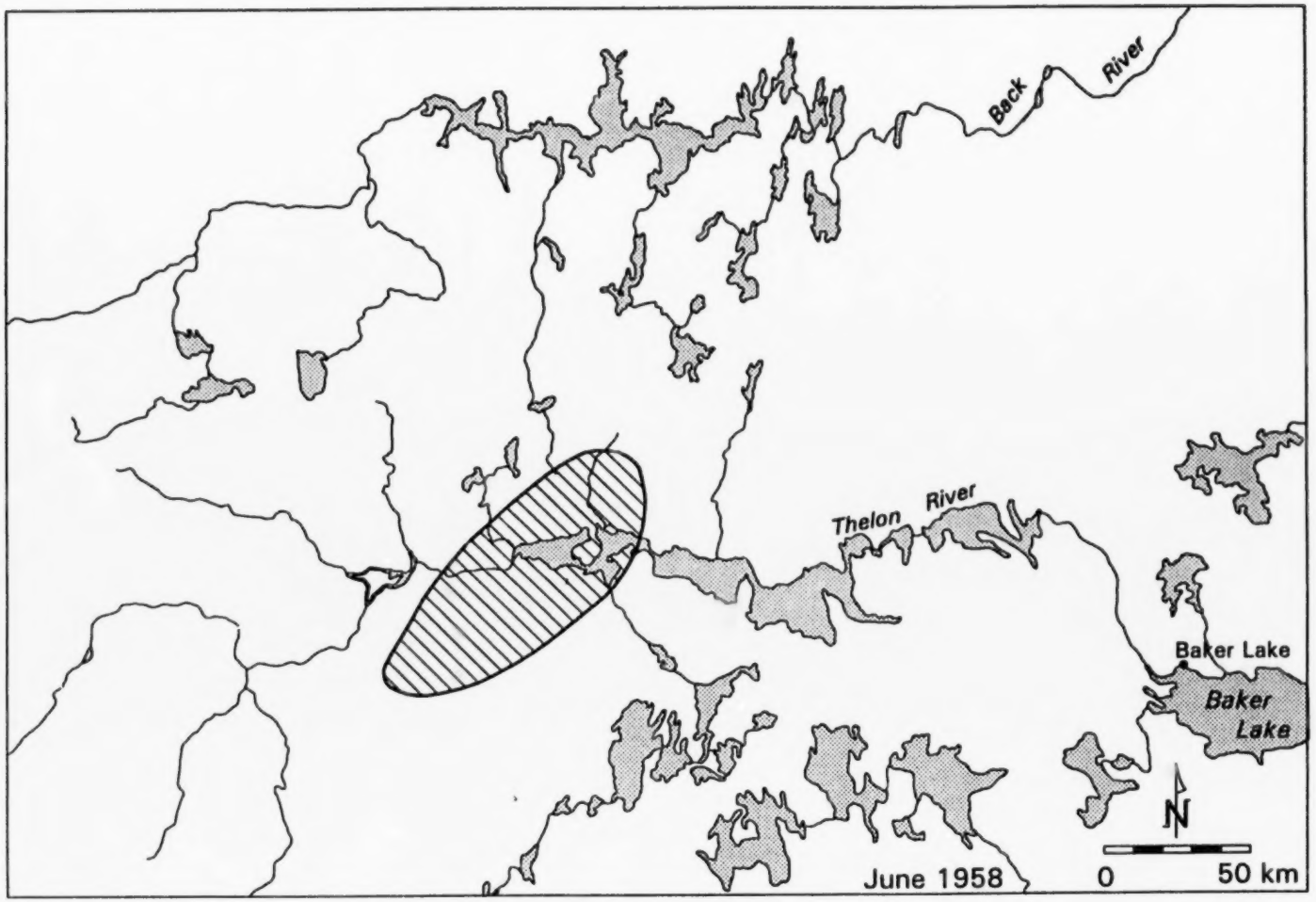

Figure 6. Beverly caribou calving distribution, June 1958 (Darby 1978, Fleck and Gunn 1982)

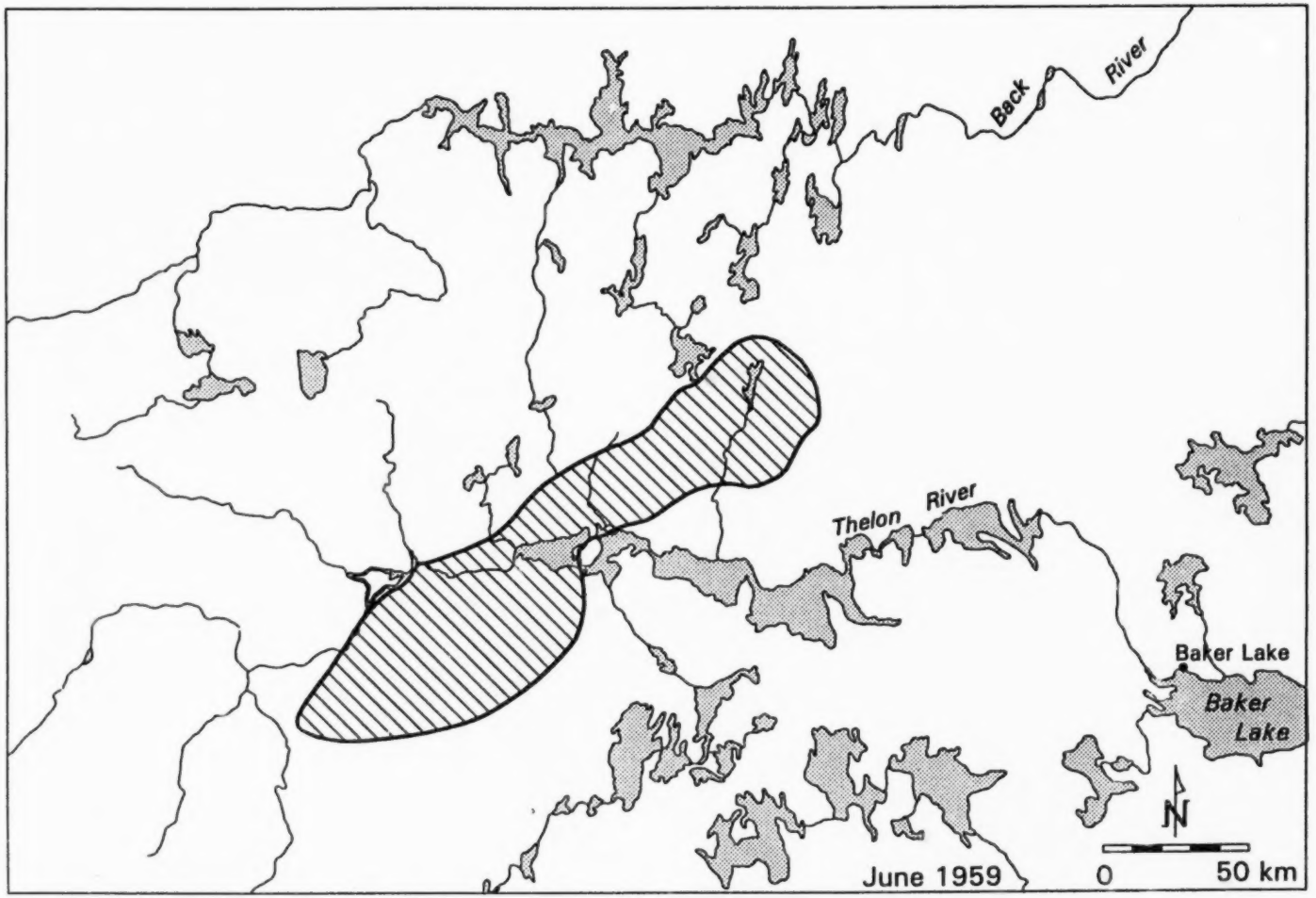

Figure 7. Beverly caribou calving distribution, 4-19 June 1959 (McEwan 1959)

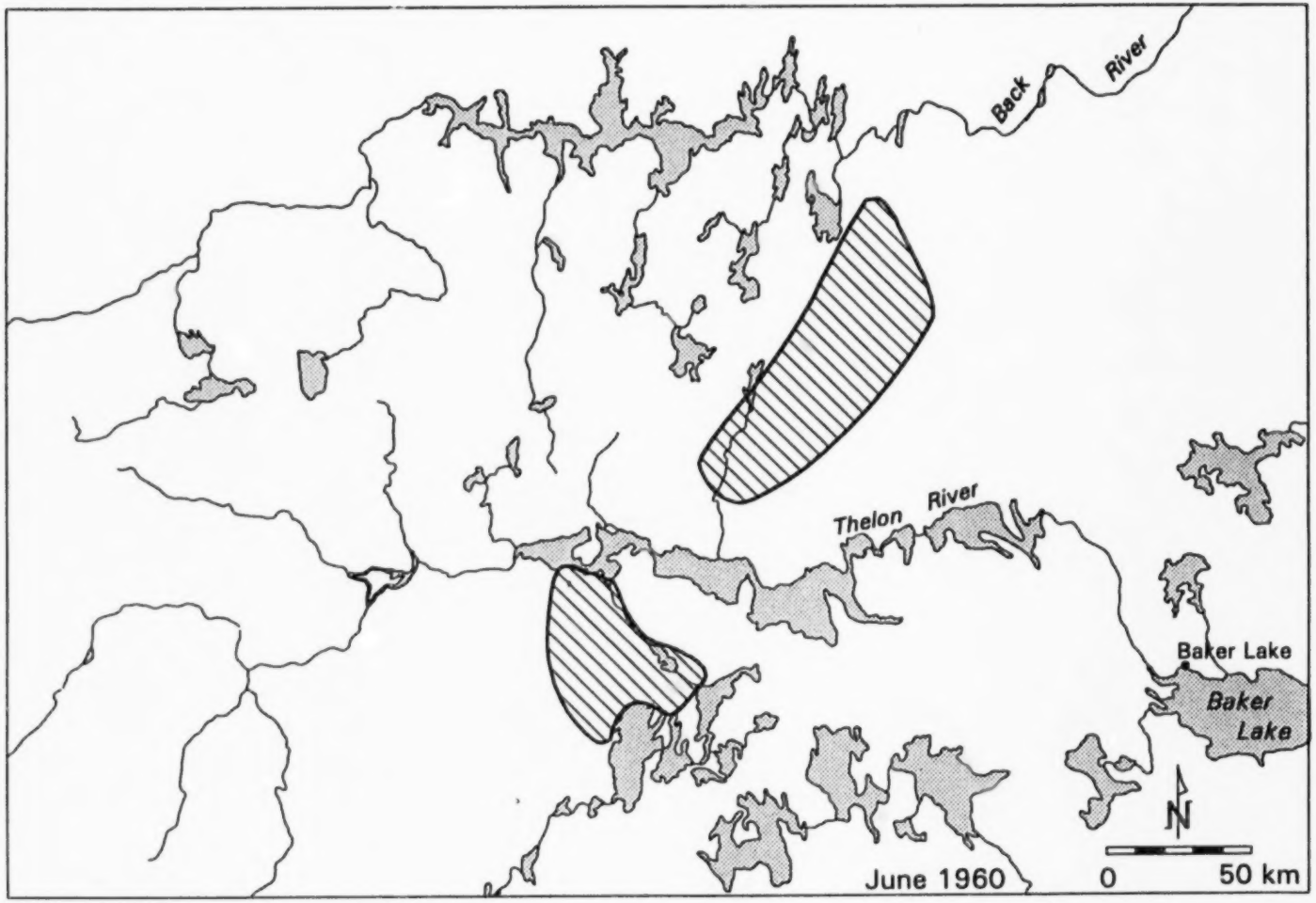

Figure 8. Beverly caribou calving distribution delineated on 7 June 1960 (Darby 1978, Fleck and Gunn 1982)

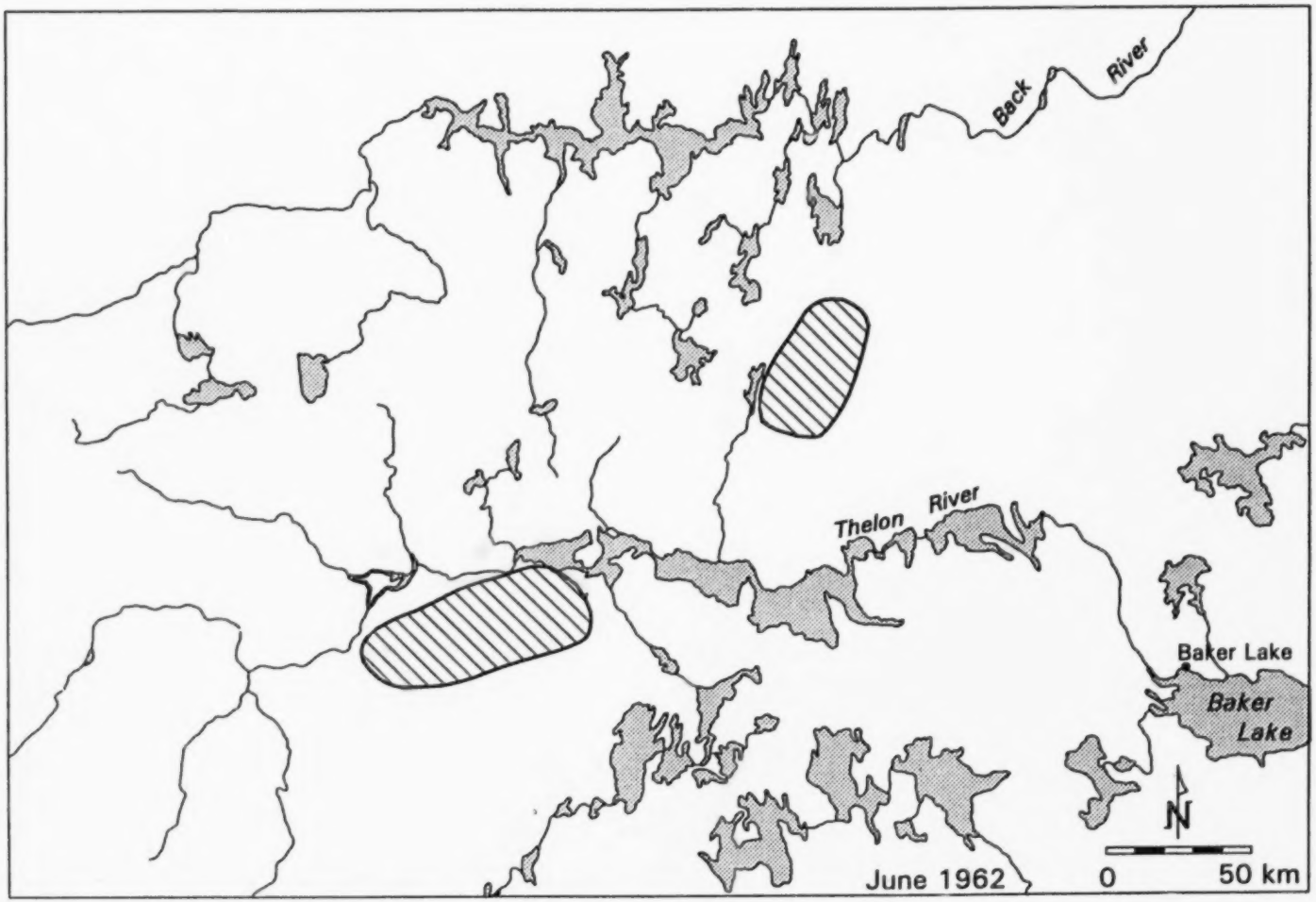

Figure 9. Beverly caribou calving distribution, June 1962 (Darby 1978)

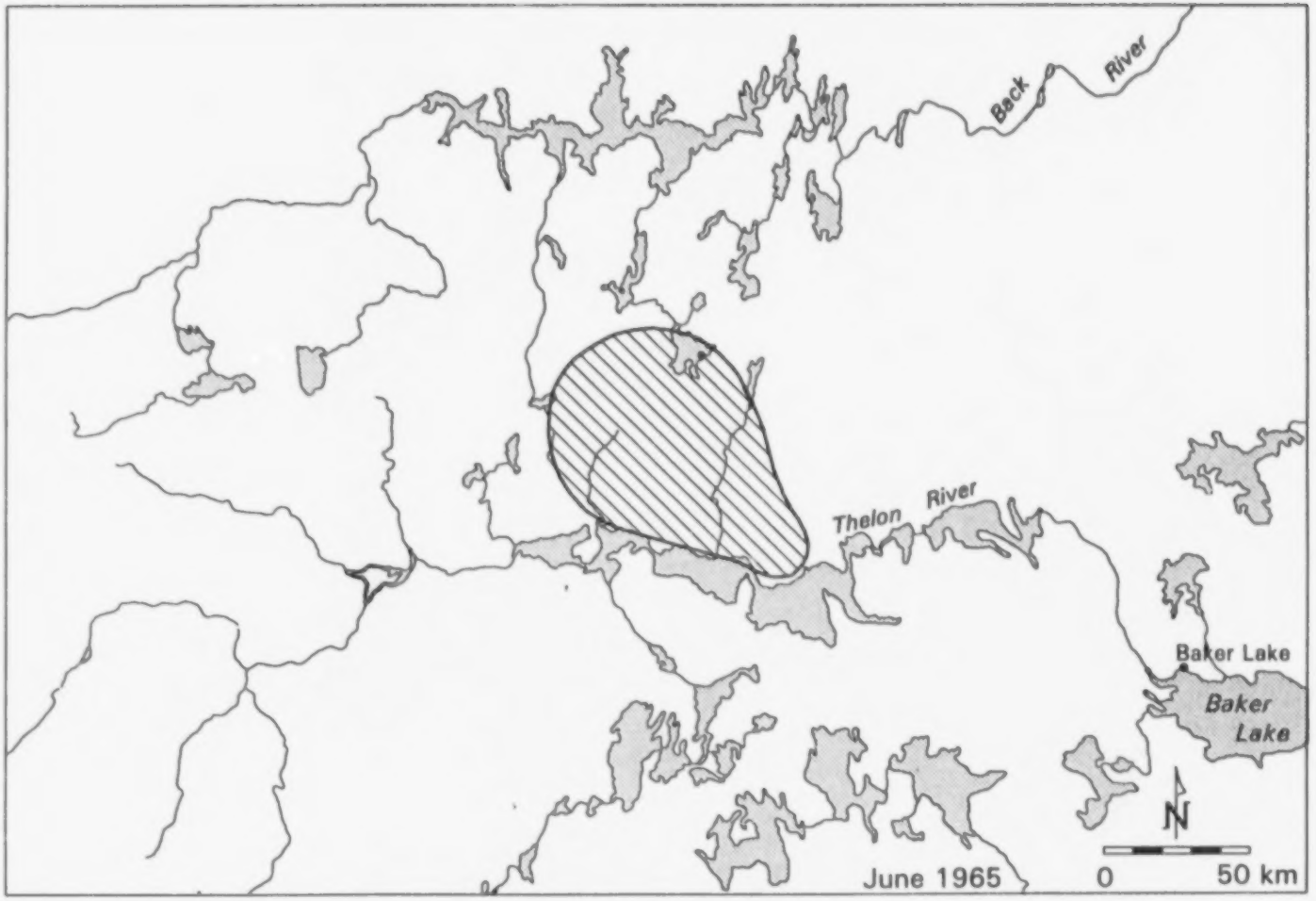

Figure 10. Beverly caribou calving distribution, June 1965 (Fleck and Gunn 1982)

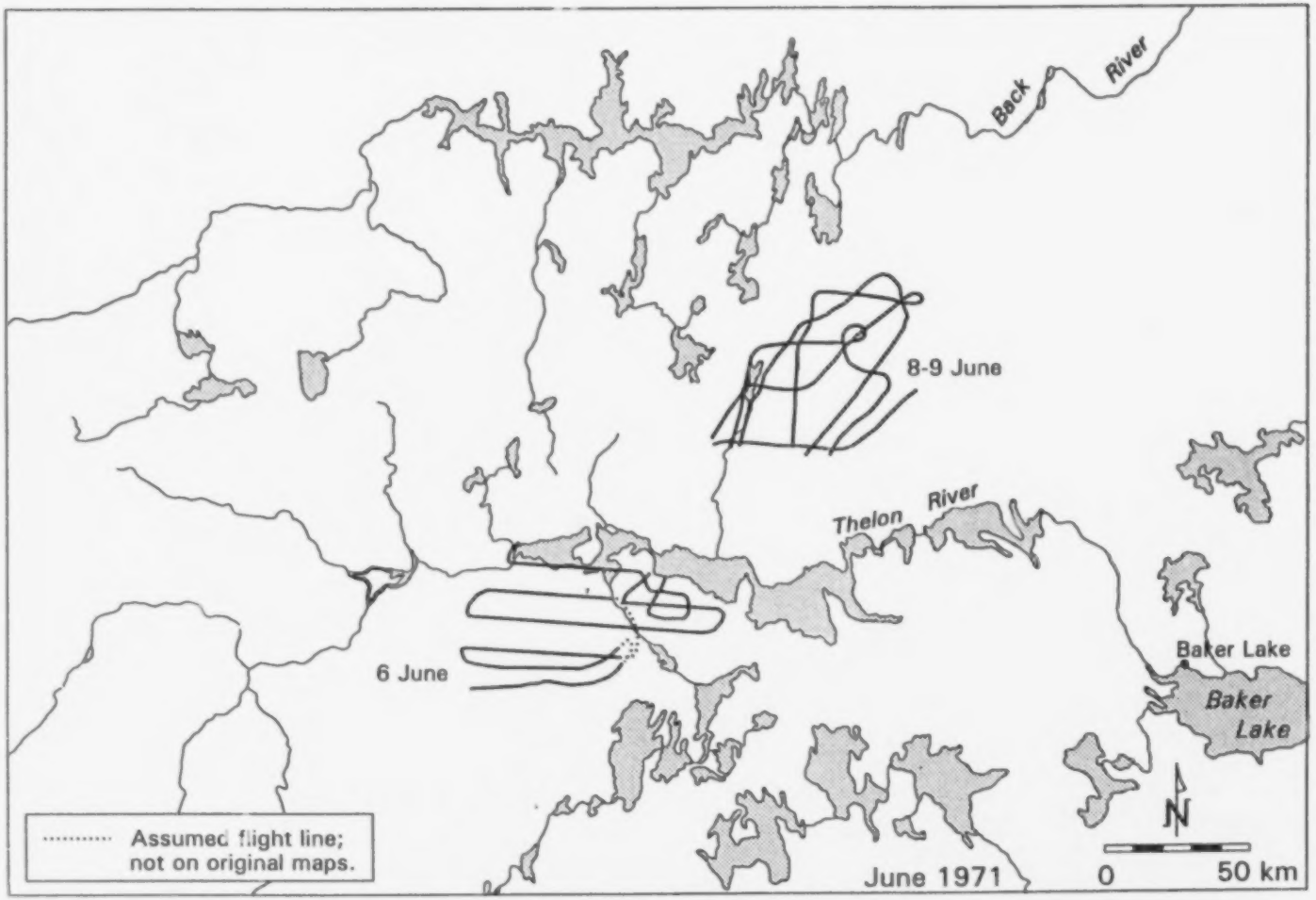

Figure 11. Lines flown to delineate the Beverly calving grounds, 6-9 June 1971 (Rippin 1971)

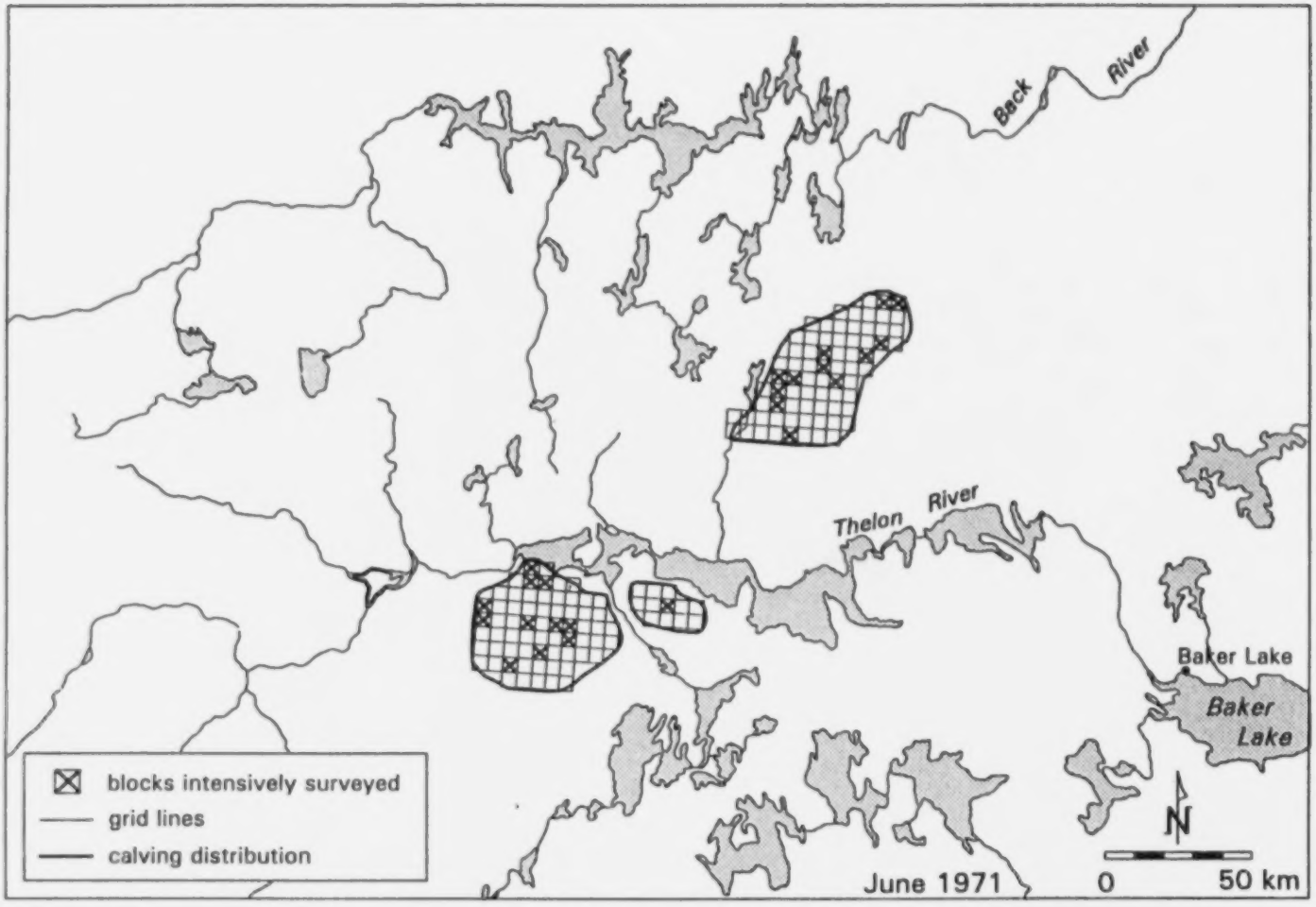

Figure 12. Beverly calving ground random block survey, 7-9 June 1971 (Rippin 1971)

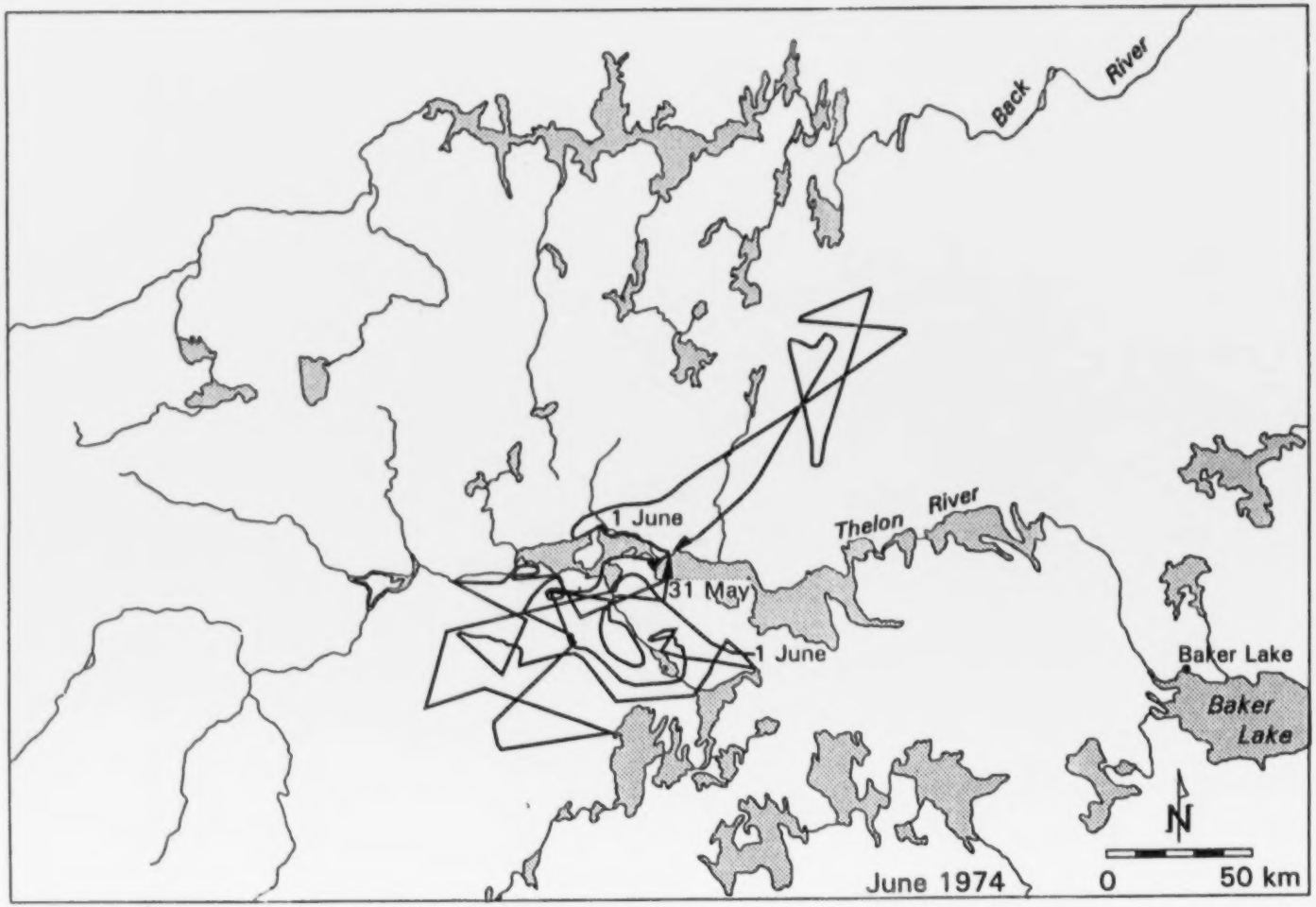

Figure 13. Beverly calving ground unsystematic reconnaissance flight lines, 31 May - 1 June 1974 (Moshenko 1974)

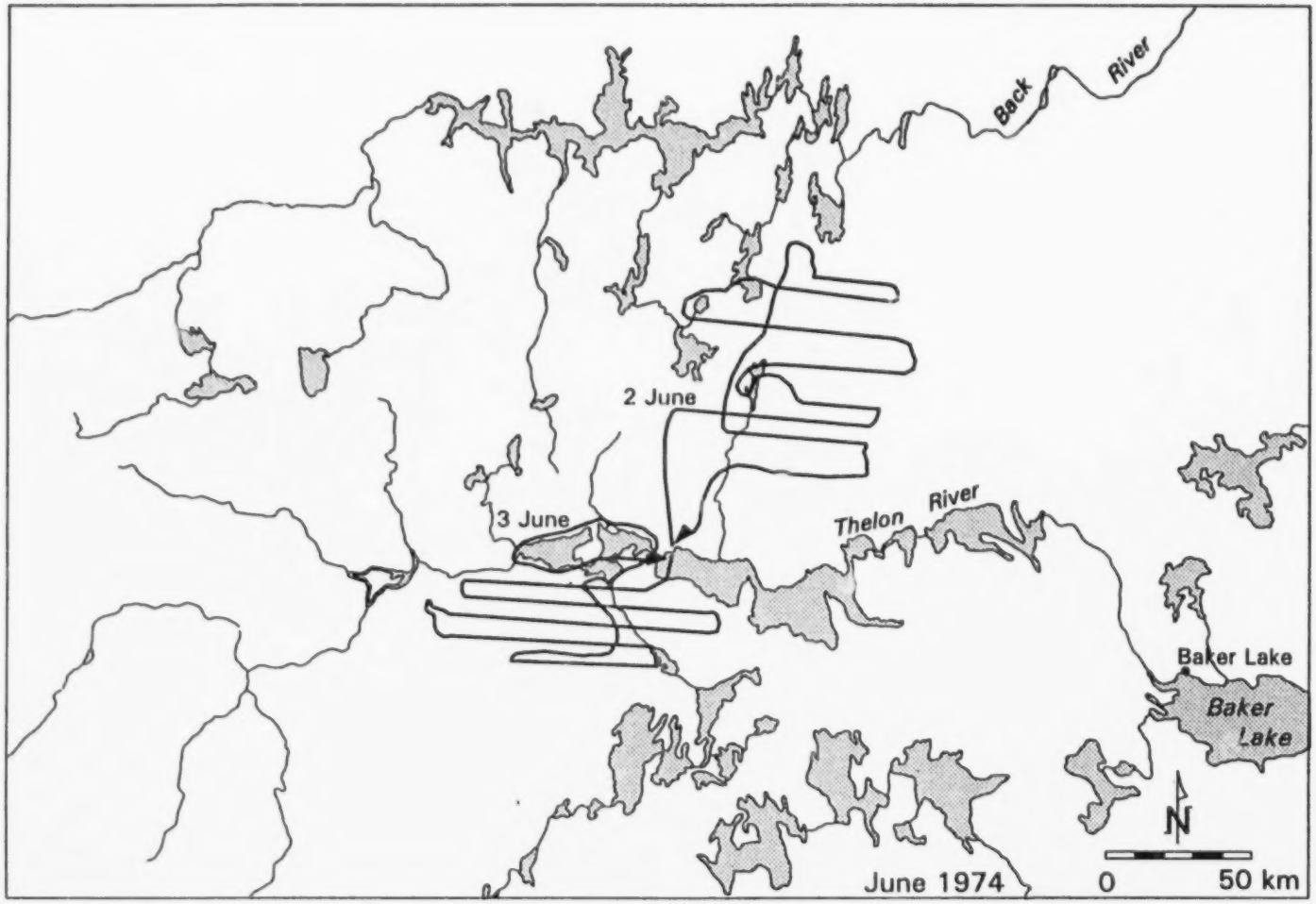

Figure 14. Lines flown to delineate the Beverly calving grounds, 2-4 June 1974 (Moshenko 1974)

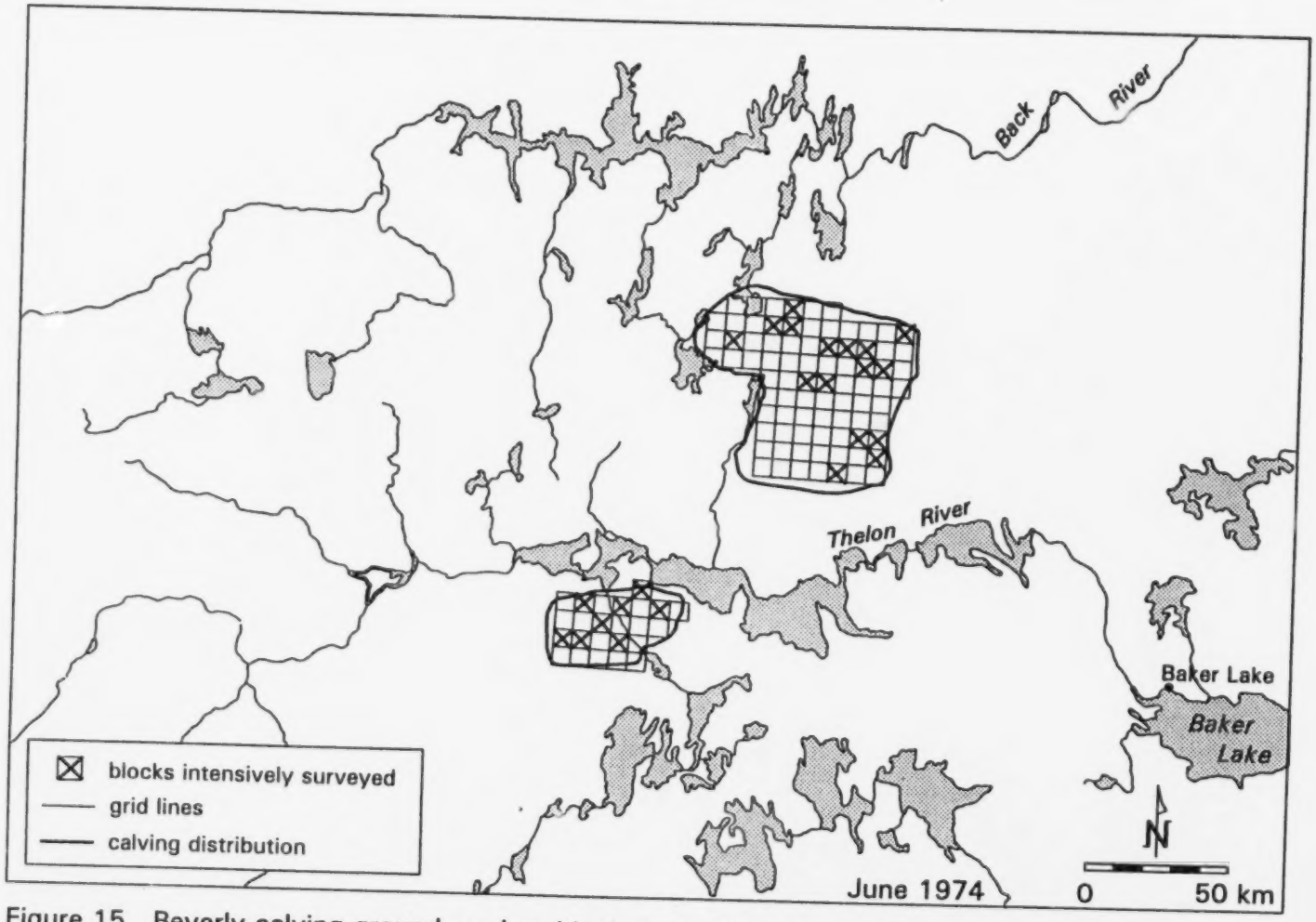

Figure 15. Beverly calving ground random block survey, 3-6 June 1974 (Moshenko 1974)

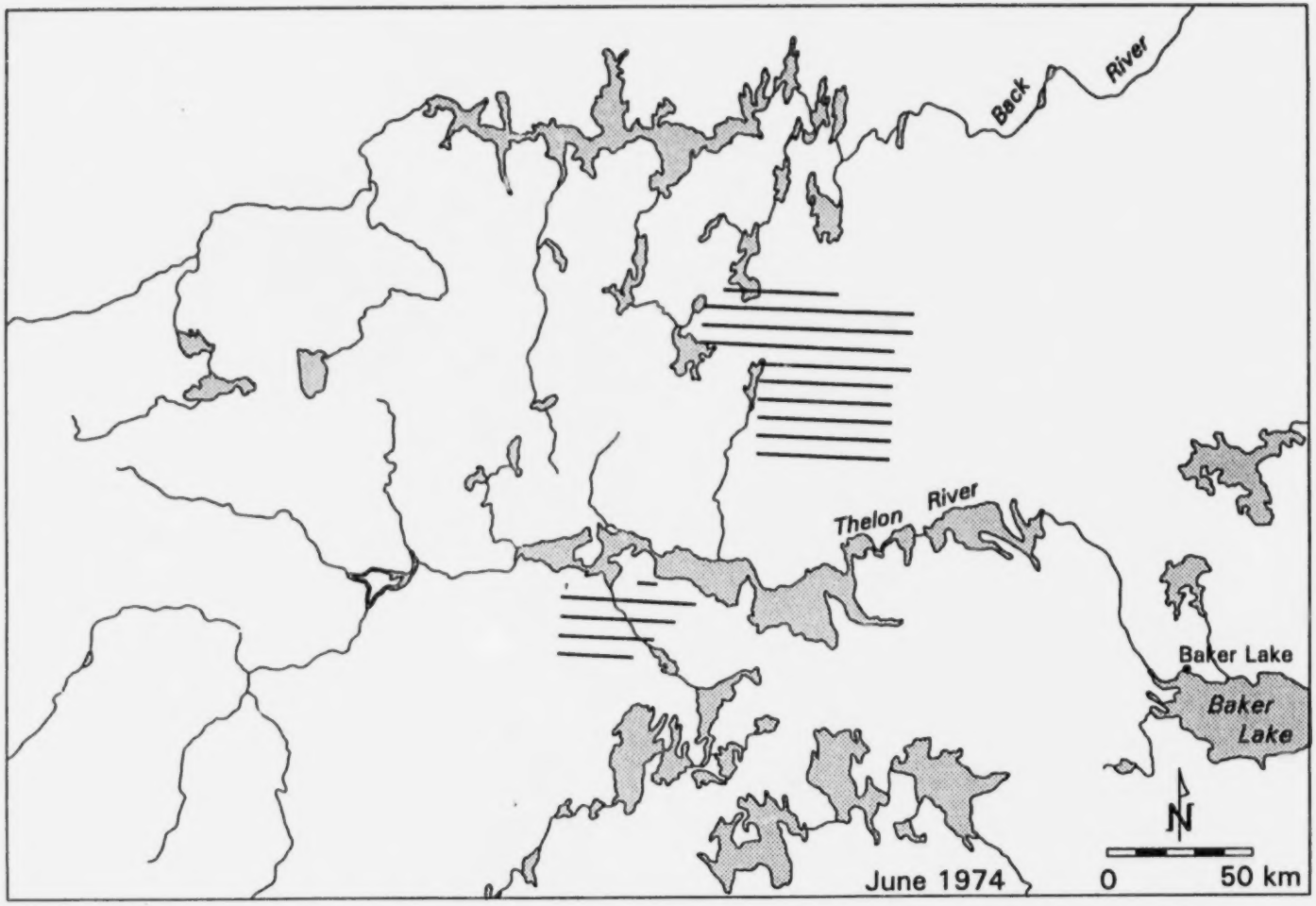

Figure 16. Beverly calving ground strip survey flight lines, 6-7 June 1974 (Moshenko 1974)

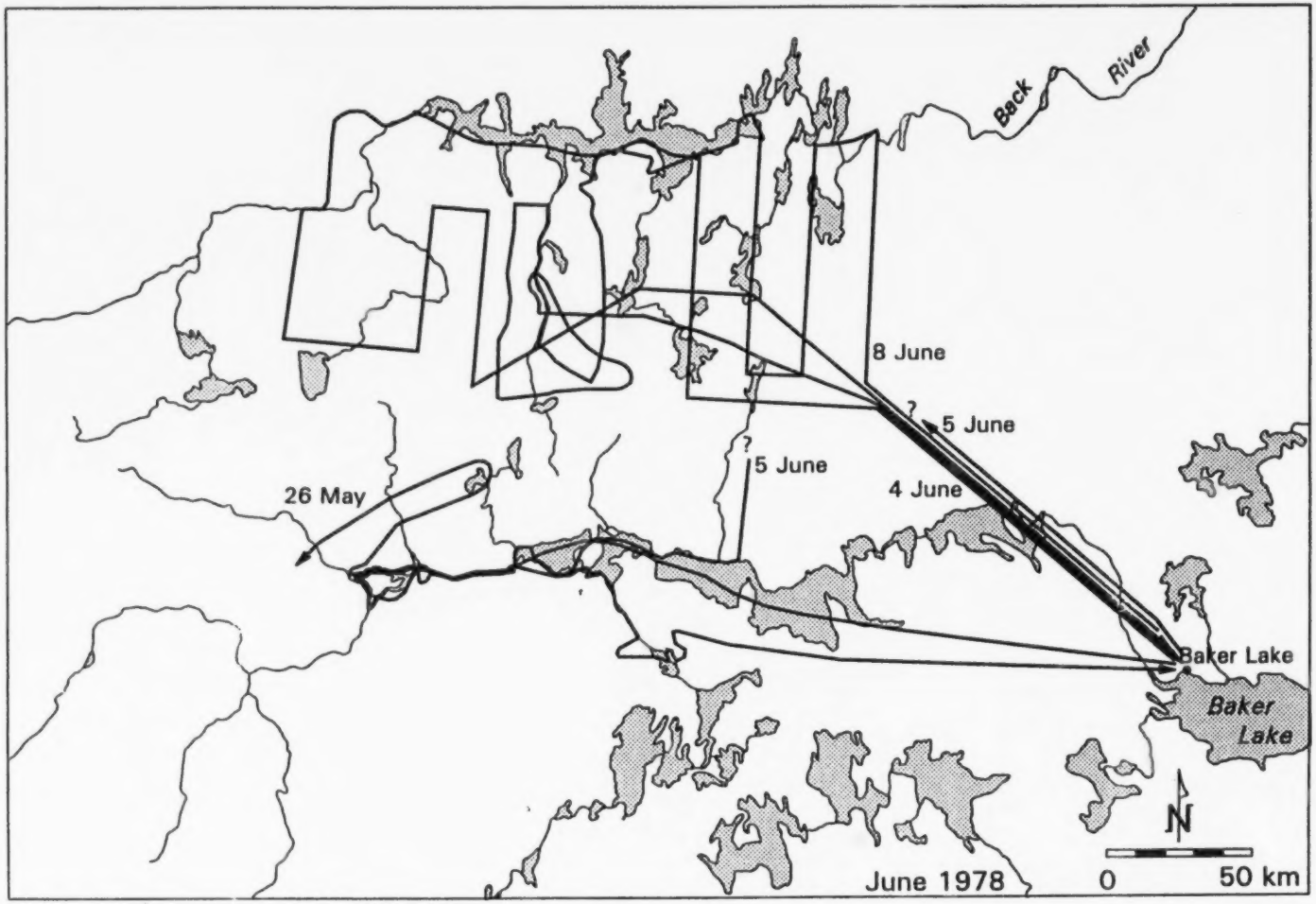

Figure 17. Beverly calving ground unsystematic reconnaissance flight lines, 26 May - 8 June 1978

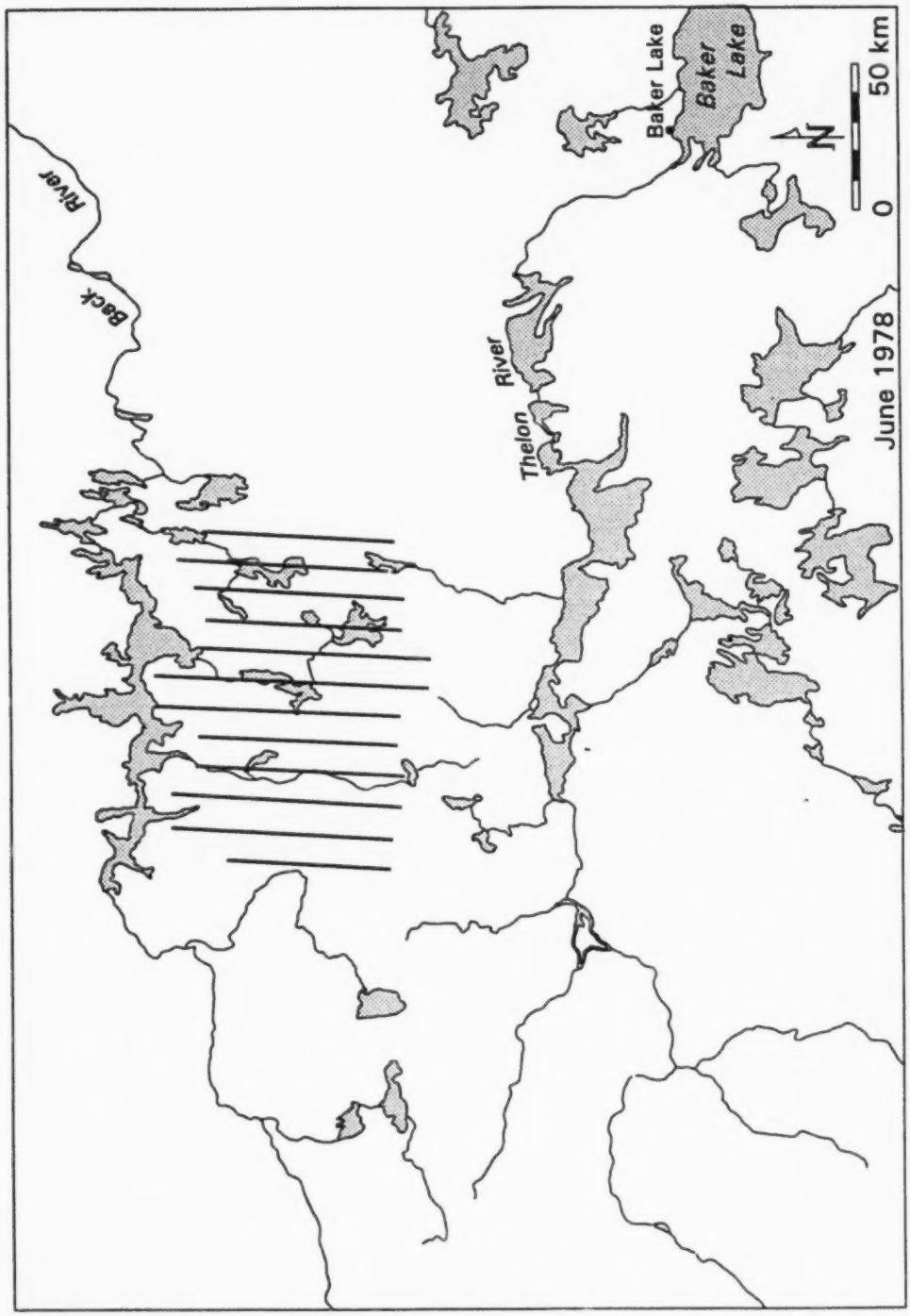

Figure 18. Beverly calving ground systematic reconnaissance flight lines, 9 June 1978

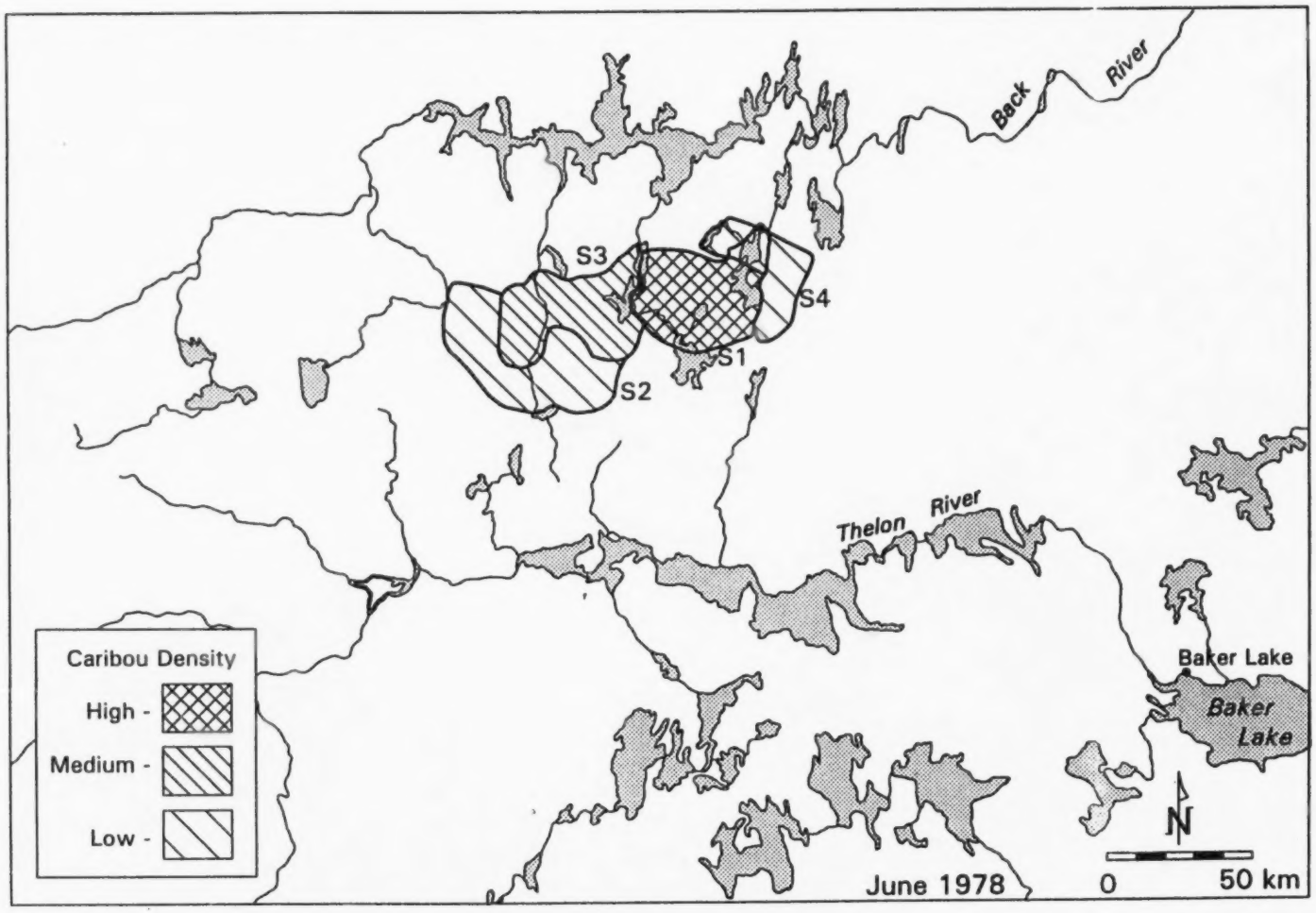

Figure 19. Beverly calving ground survey strata, 9 June 1978

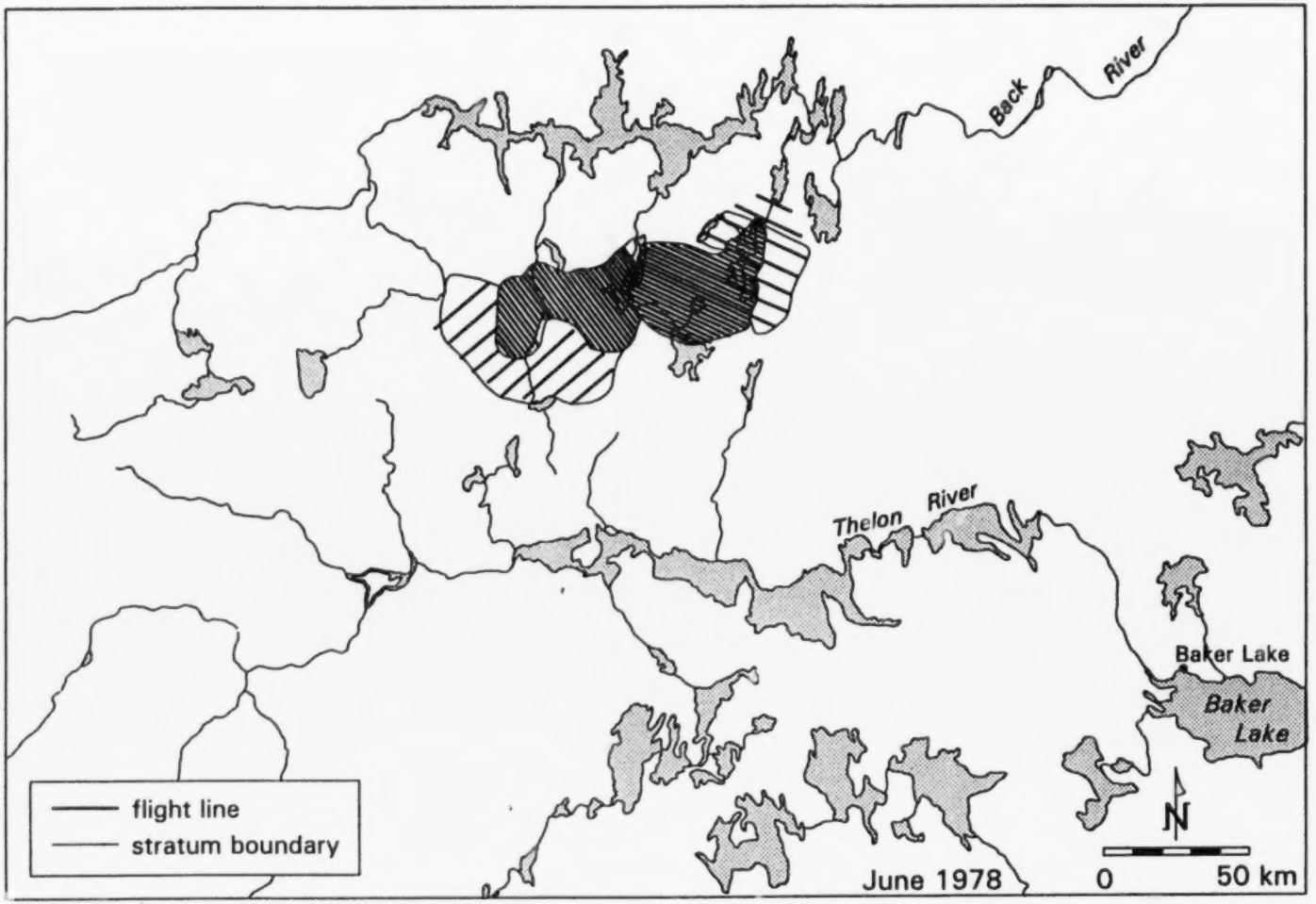

Figure 20. Beverly calving ground stratified transect survey flight lines, 10-11 June 1978

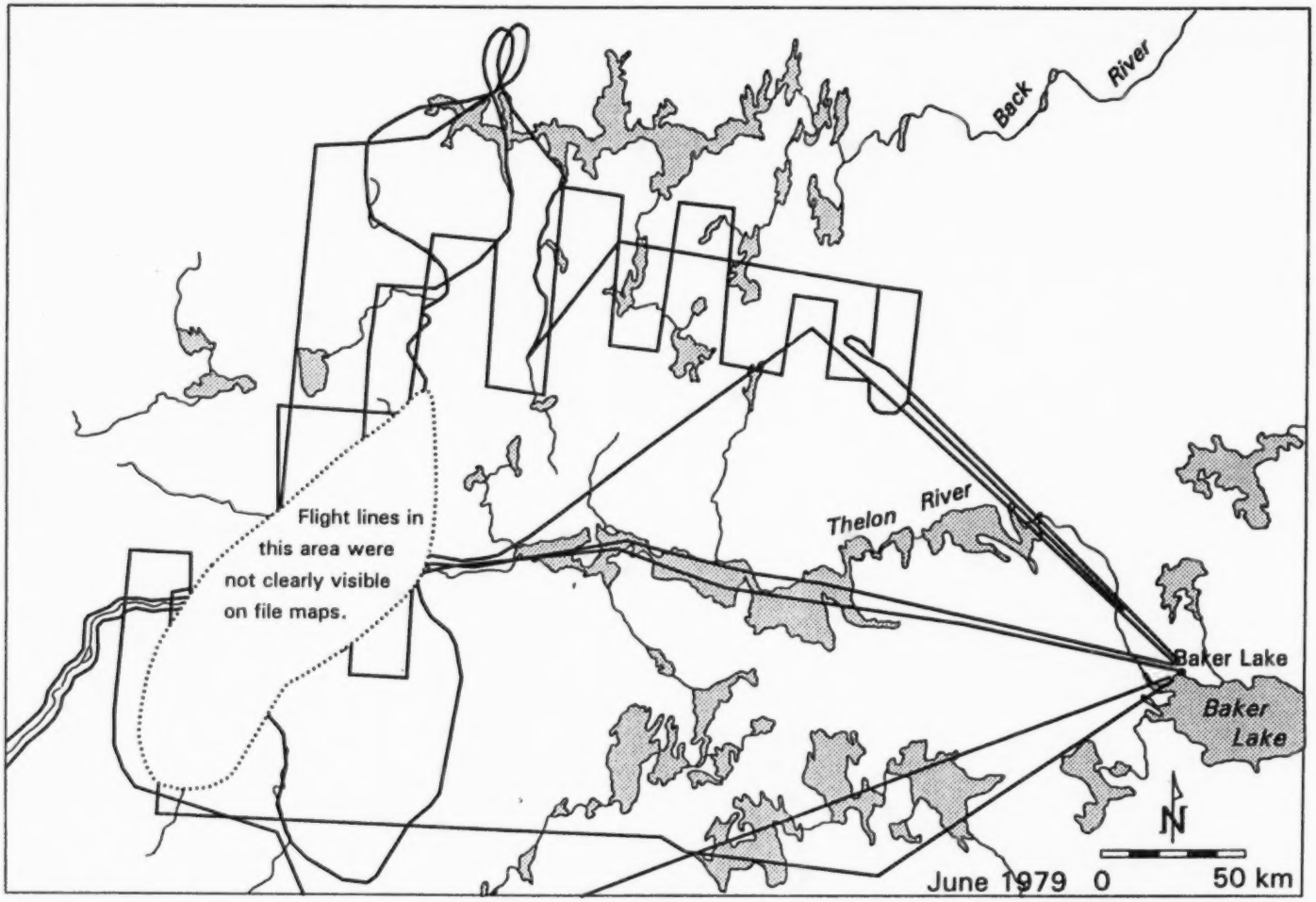

Figure 21. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 4-9 June 1979

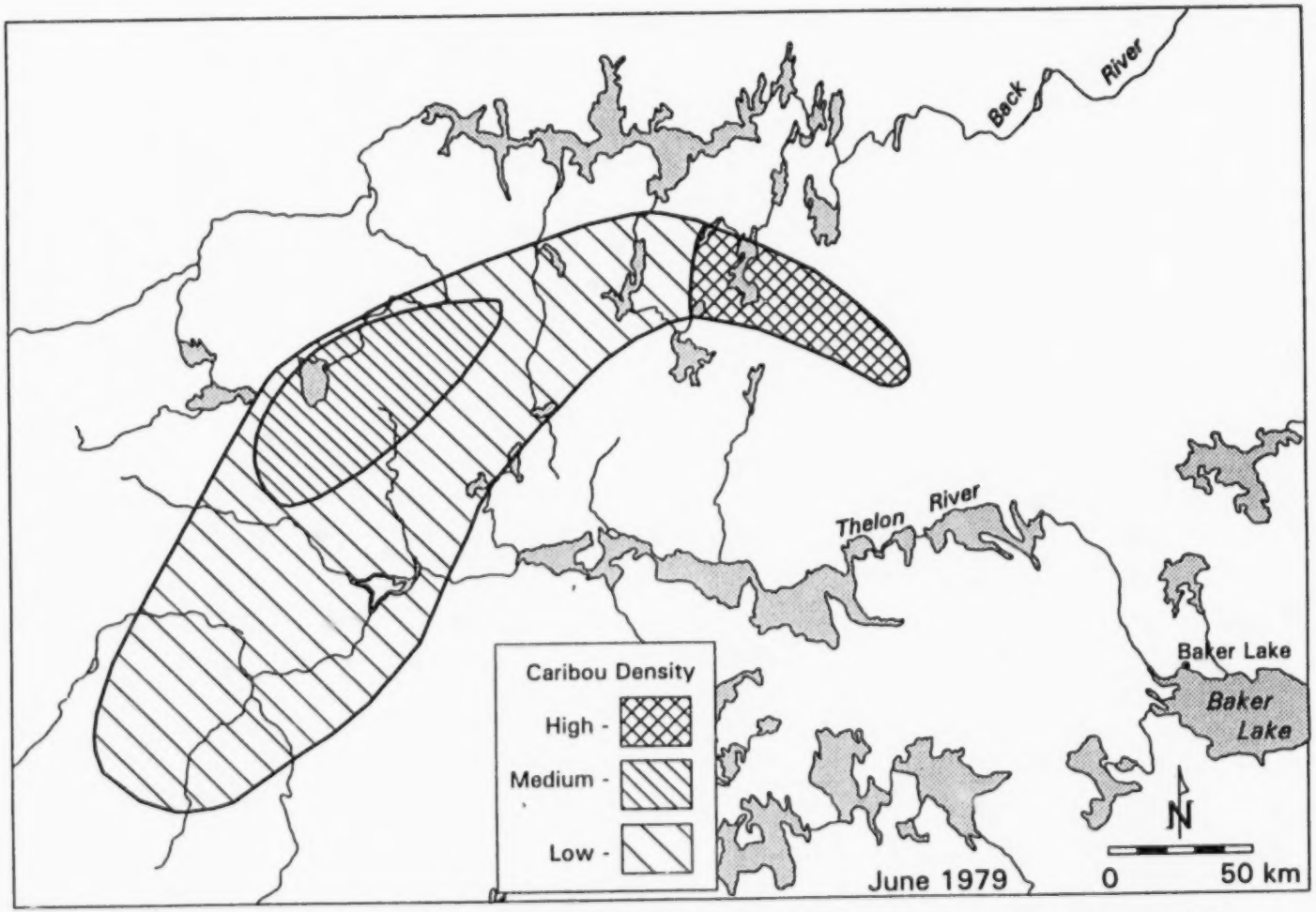

Figure 22. Distribution of cows on the Beverly calving grounds, 4-9 June 1979 (Darby 1980)

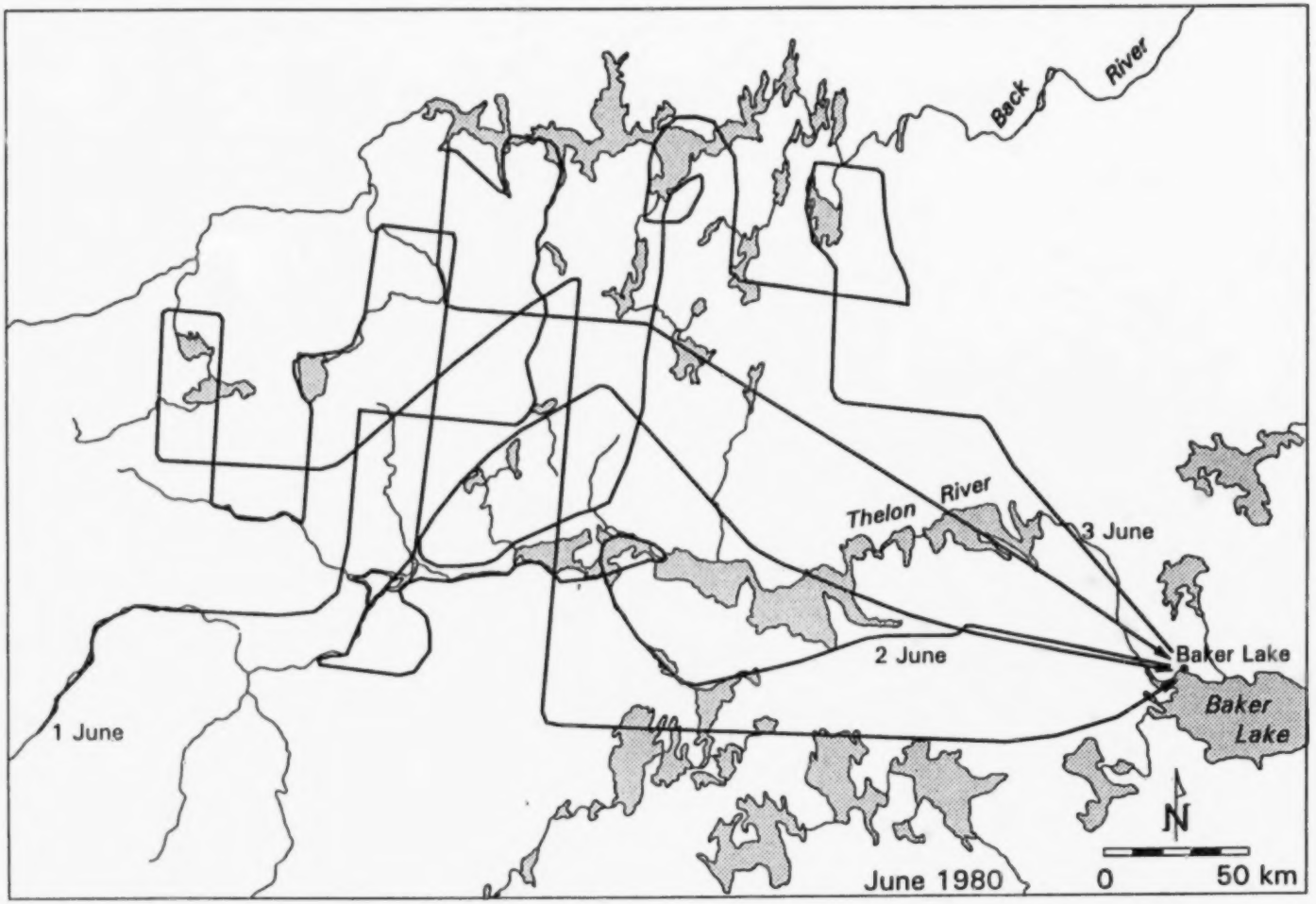

Figure 23. Beverly calving ground unsystematic reconnaissance flight lines, 1-3 June 1980

Figure 24. Beverly calving ground systematic reconnaissance flight lines, 5 June 1980

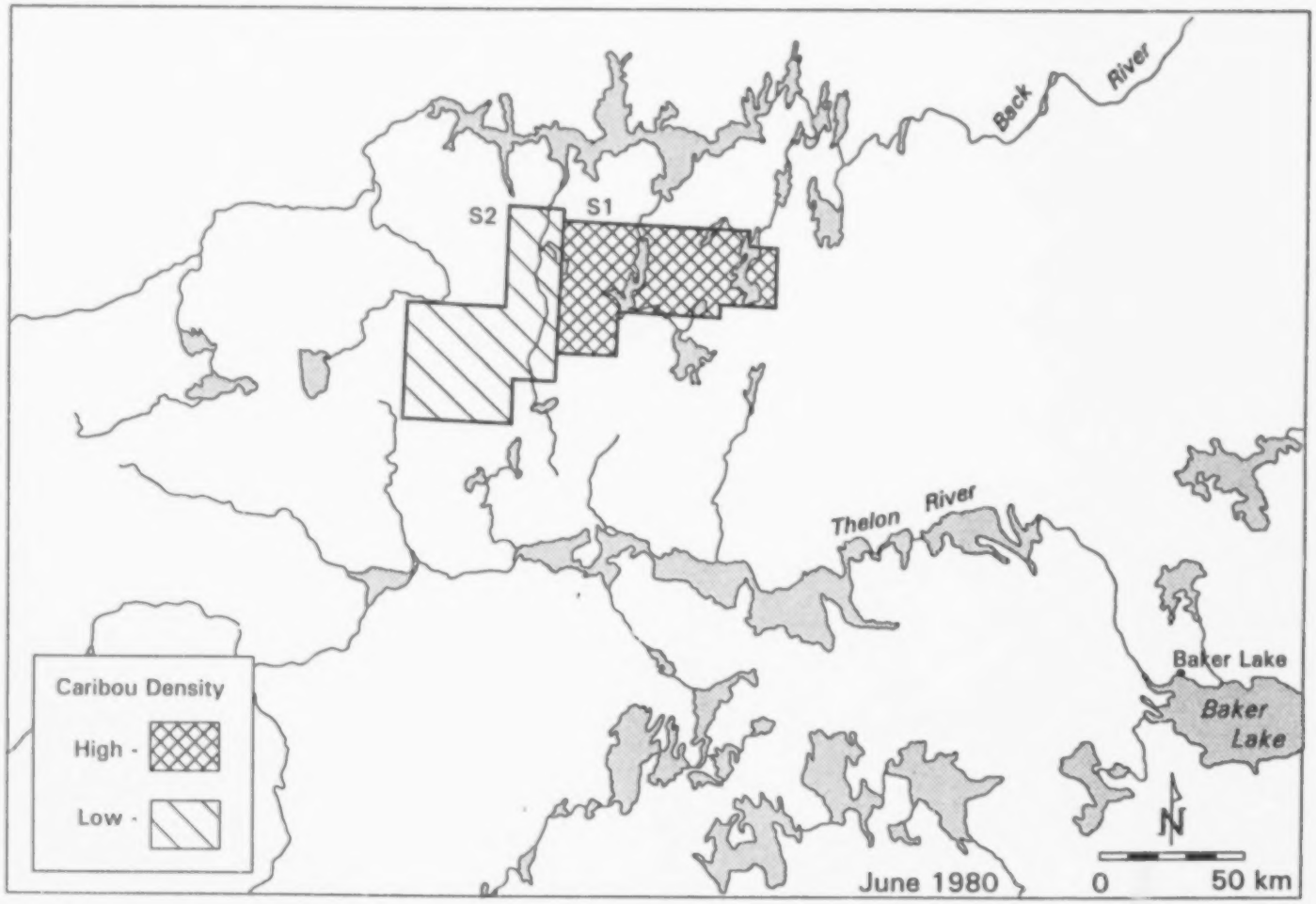

Figure 25. Beverly calving ground survey strata, 5 June 1980.

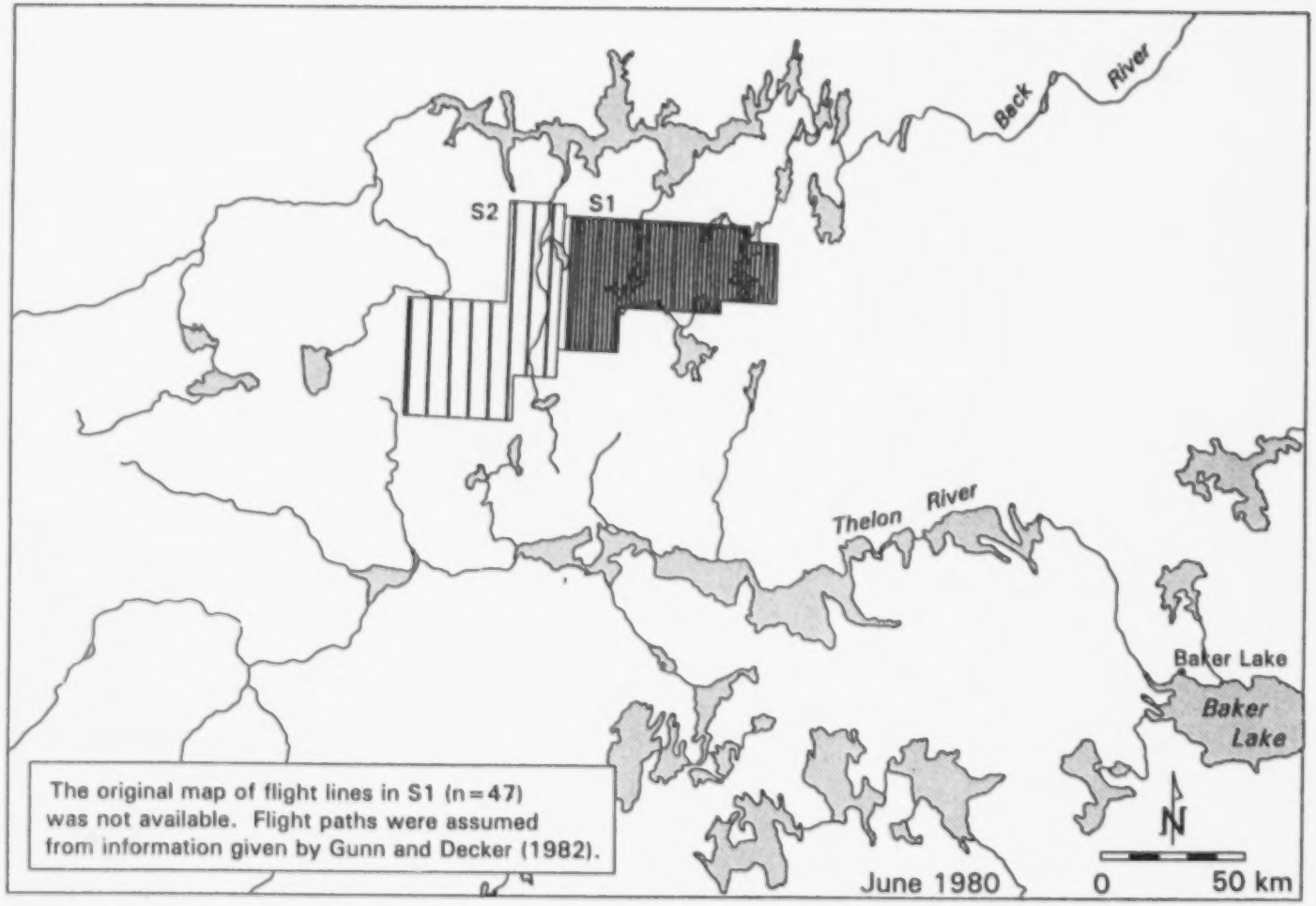

Figure 26. Beverly calving ground stratified transect survey flight lines, 6-8 June 1980

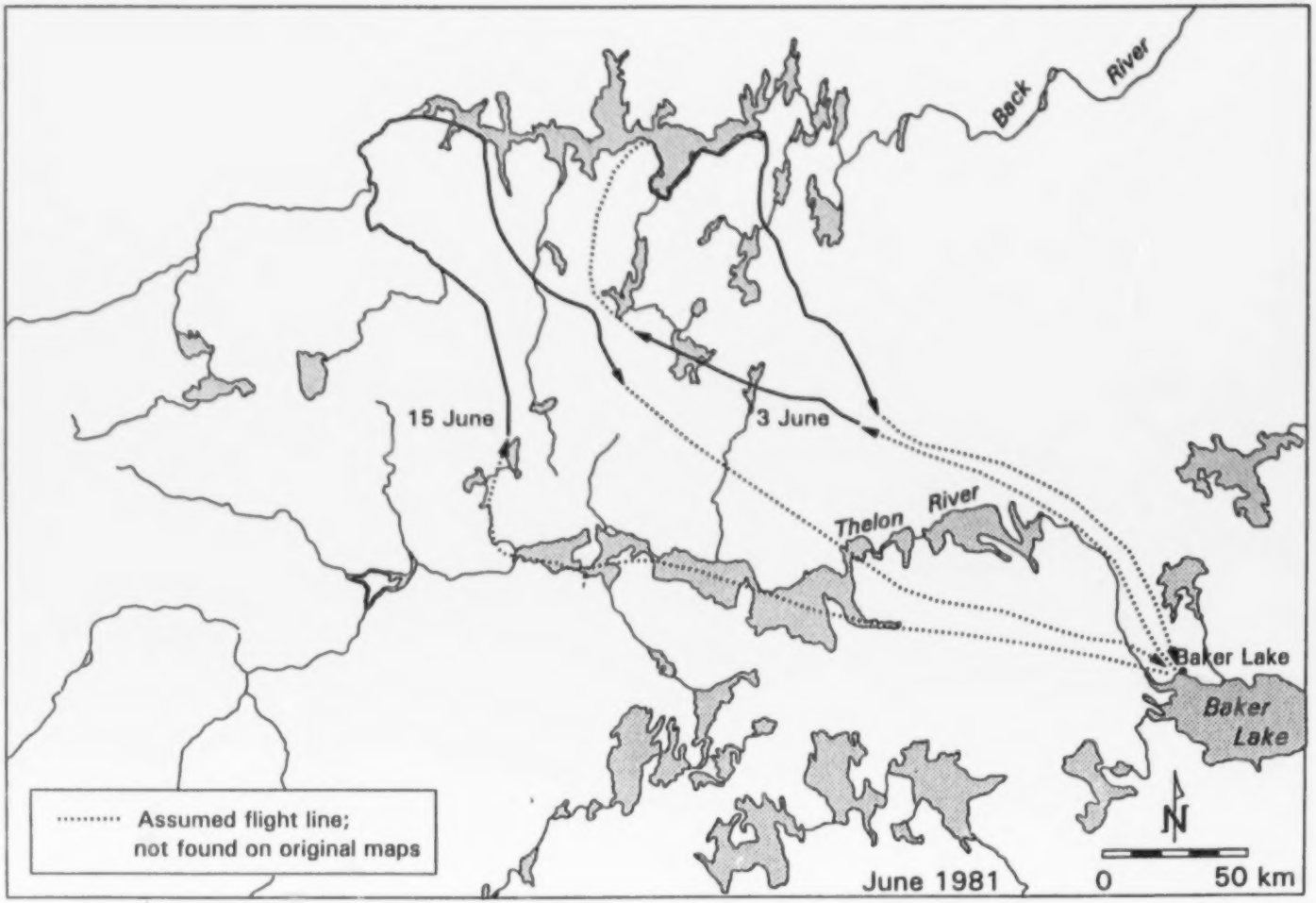

Figure 27. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 3 and 15 June 1981.

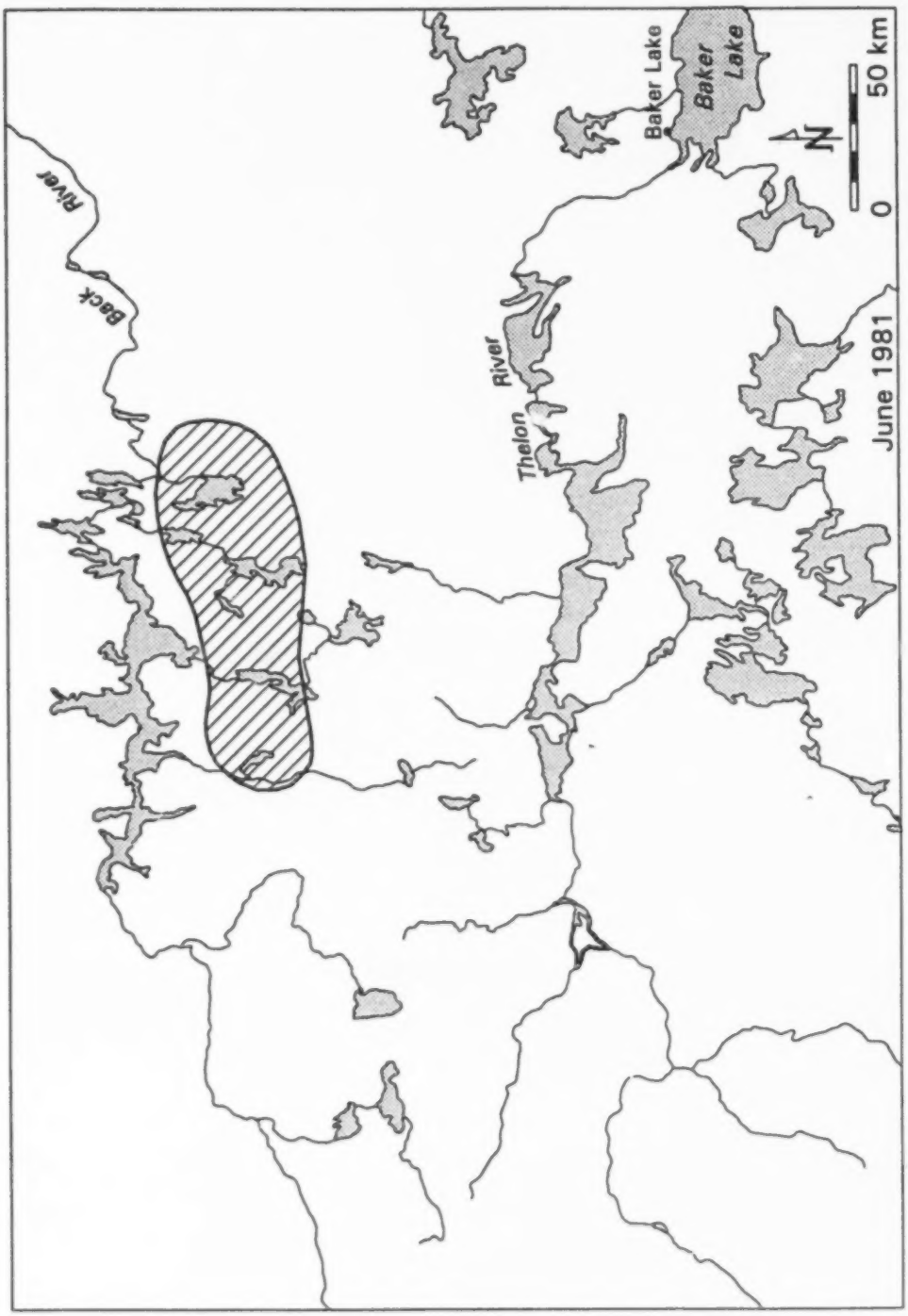

Figure 28. Distribution of cows on the Beverly calving grounds, 23 May - 15 June 1981. Boundaries are approximate (Clement 1982).

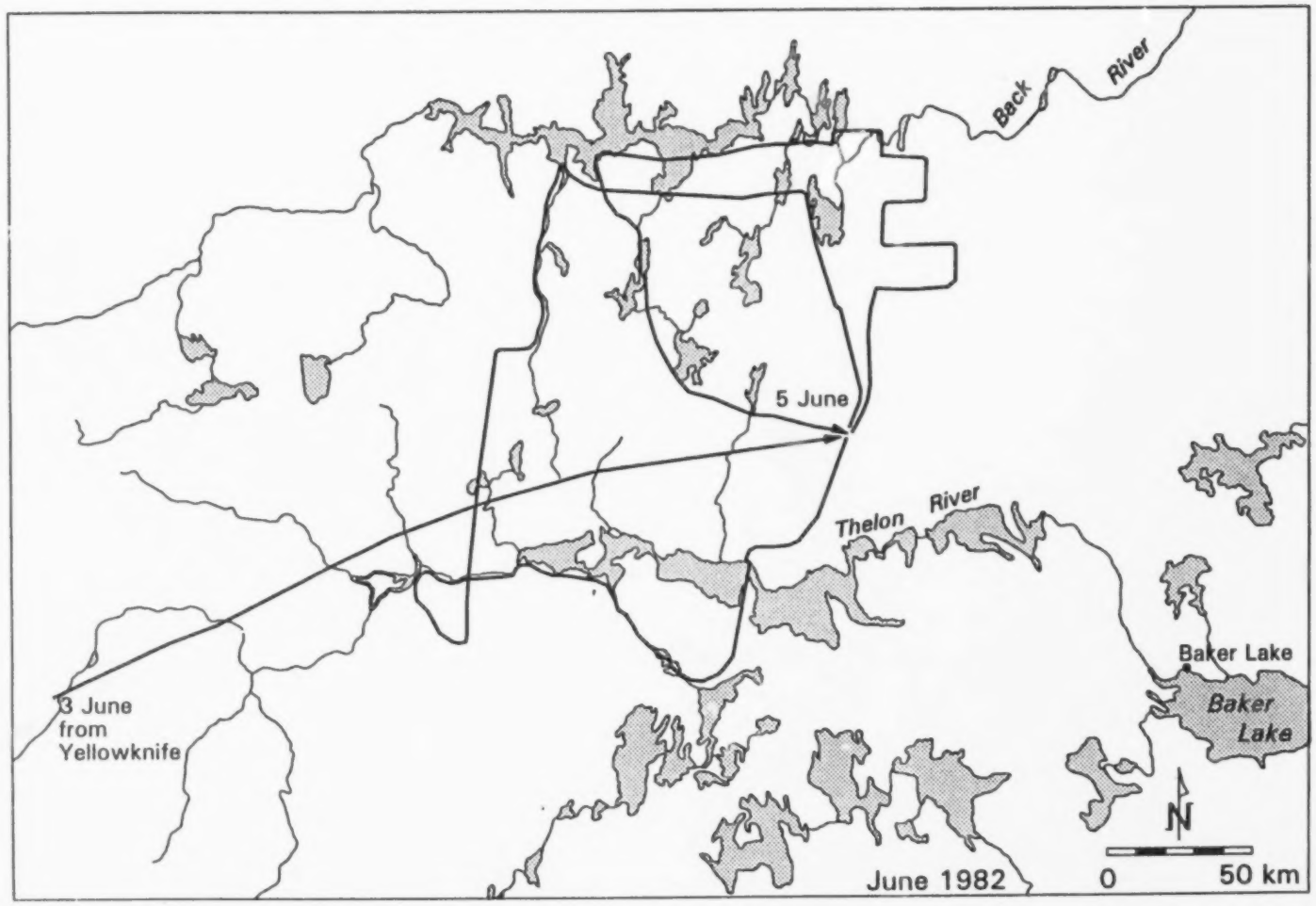

Figure 29. Beverly calving ground unsystematic reconnaissance flight lines, 5 June 1982

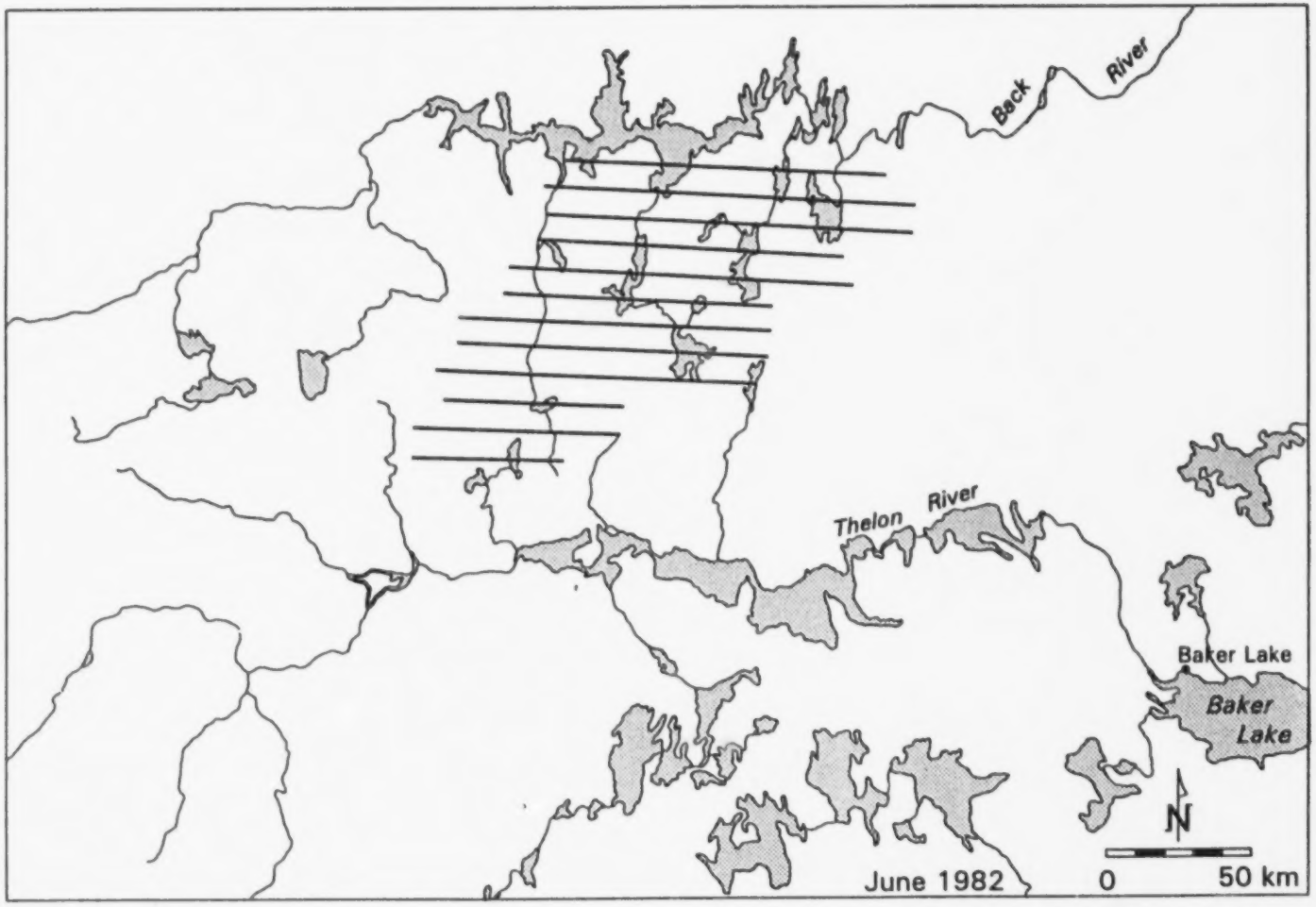

Figure 30. Beverly calving ground systematic reconnaissance flight lines, 8-9 June 1982

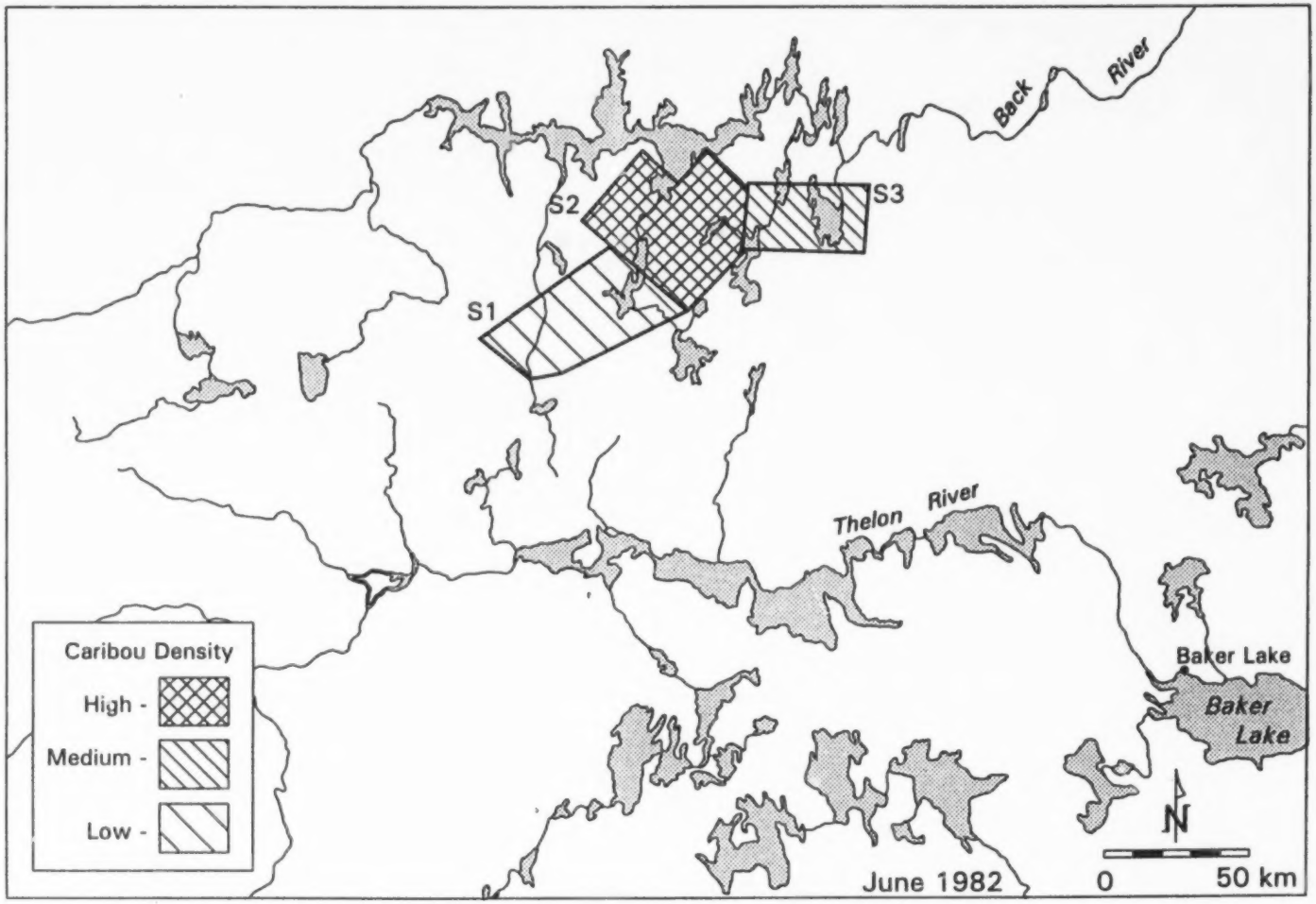

Figure 31. Beverly calving ground survey strata, 8-9 June 1982

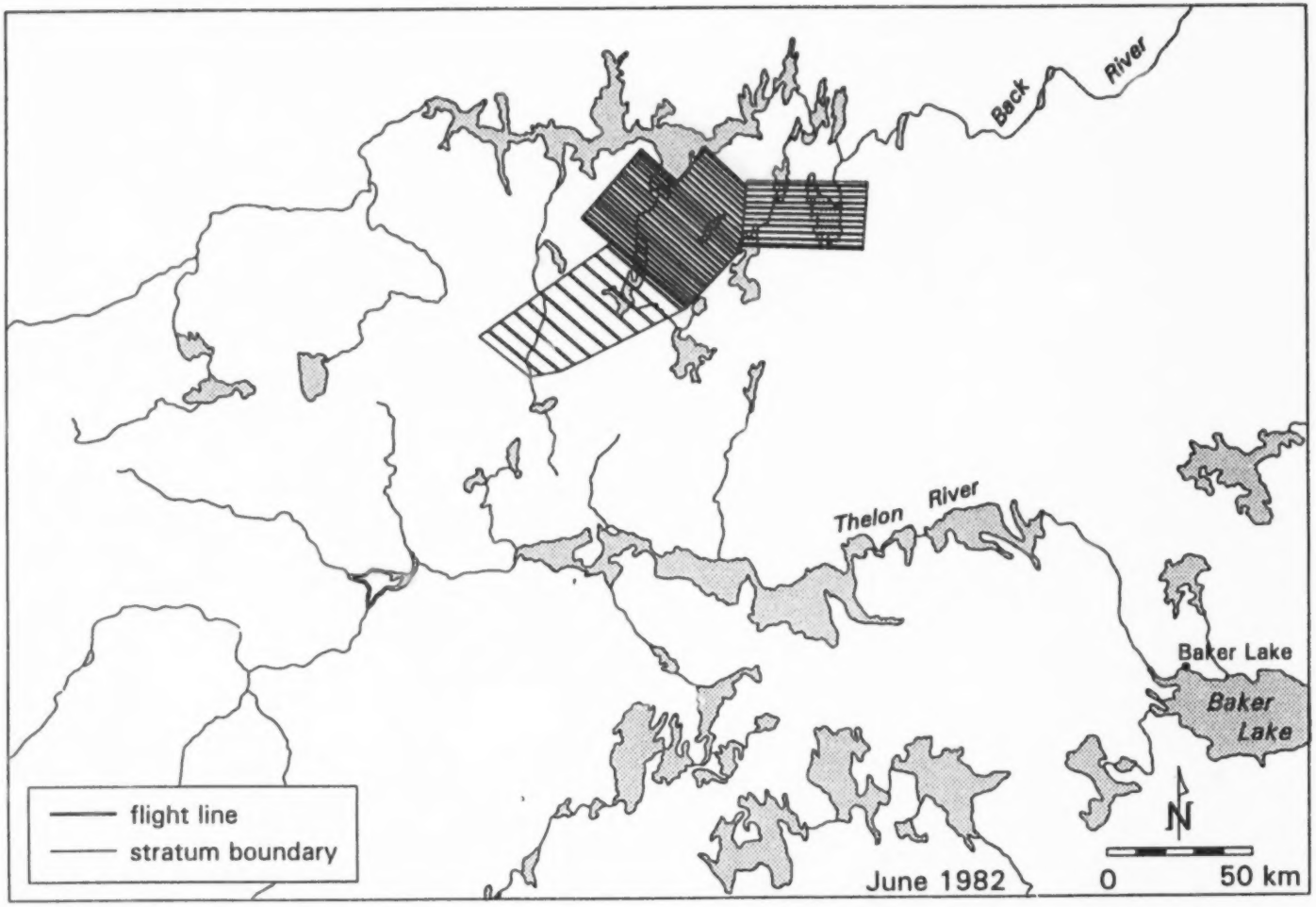

Figure 32. Beverly calving ground stratified transect survey flight lines, 11-12 June 1982

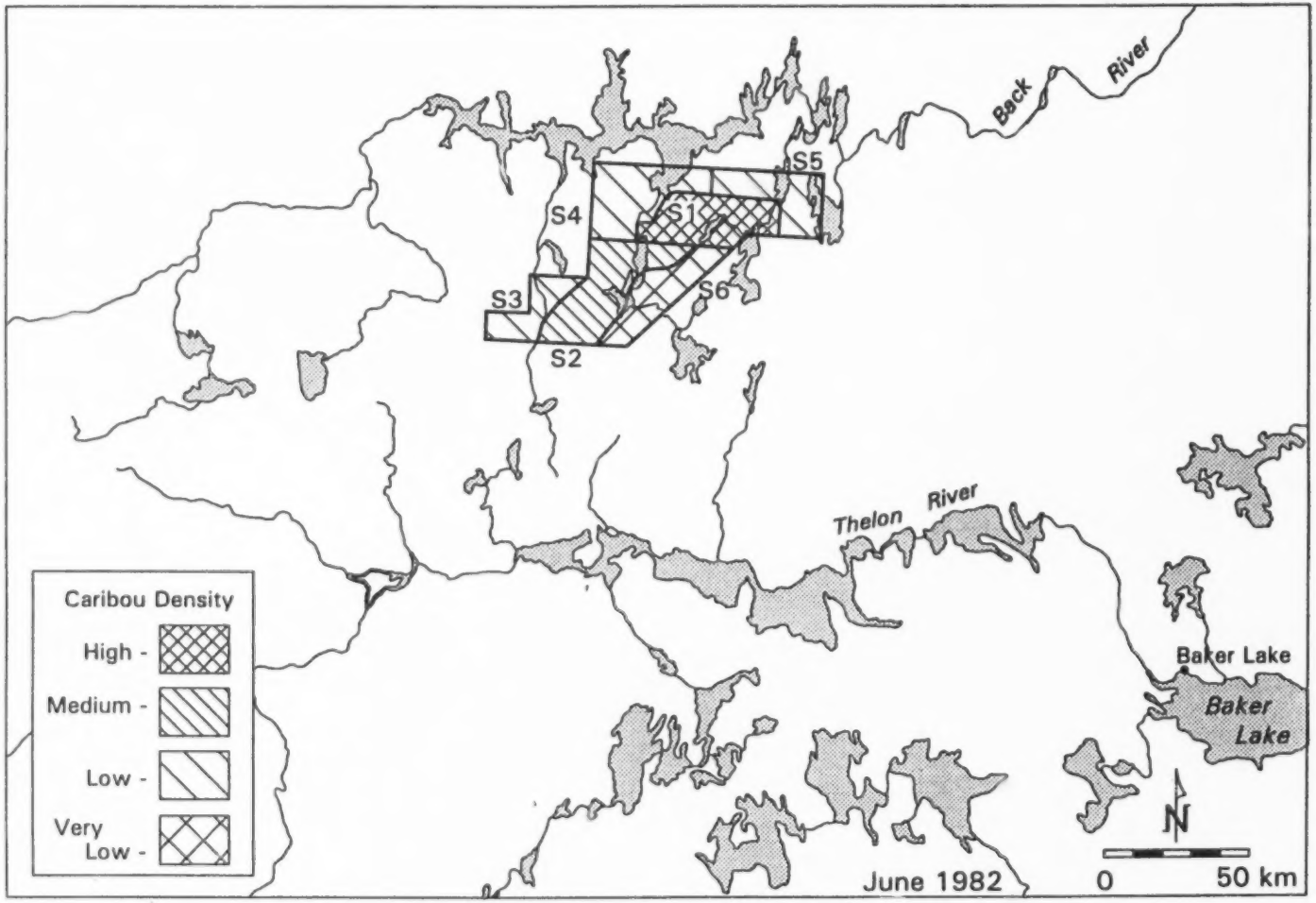

Figure 33. Beverly calving ground photographic survey strata, 12-13 June 1982

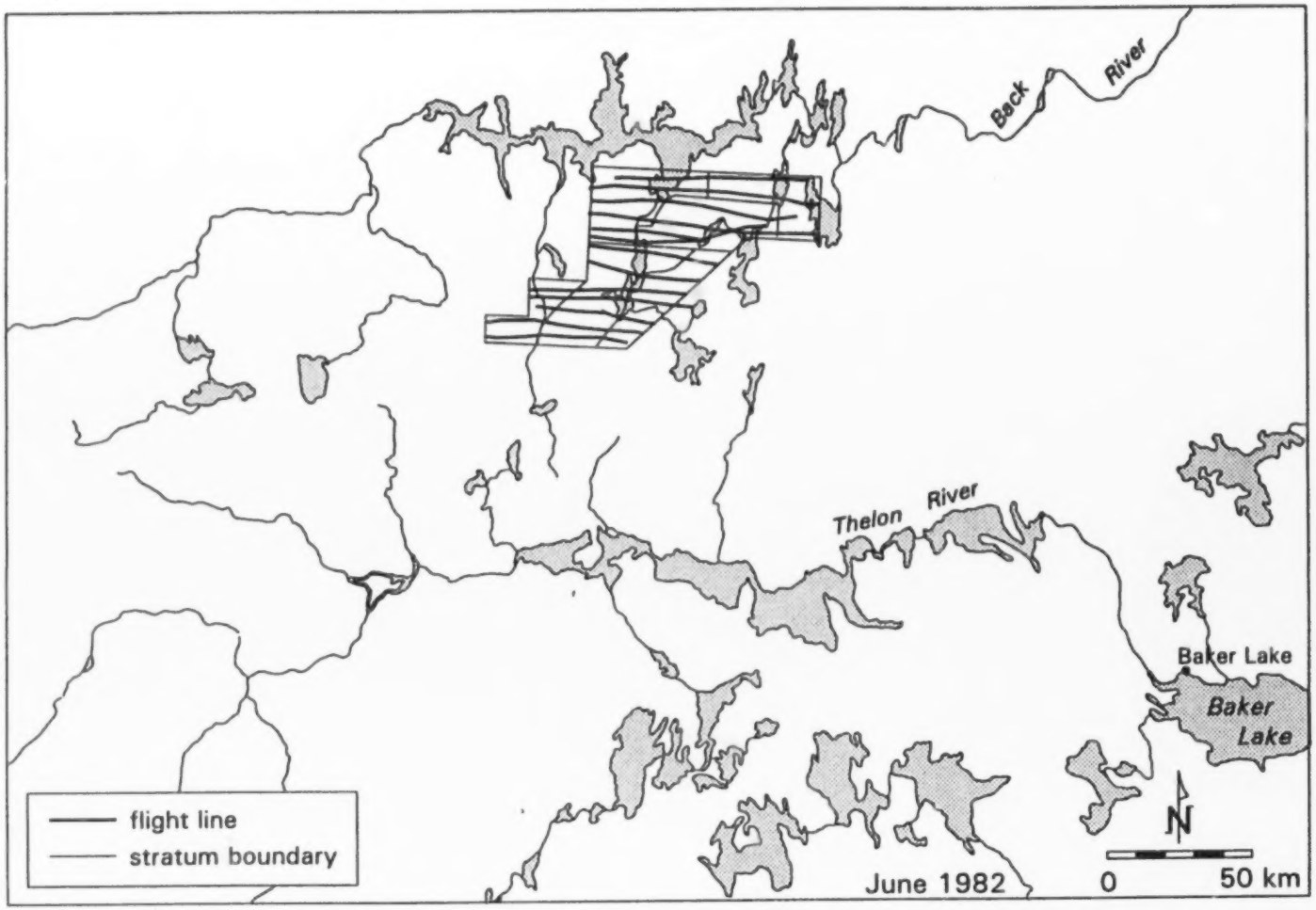

Figure 34. Beverly calving ground photographic survey flight lines, 12-13 June 1982

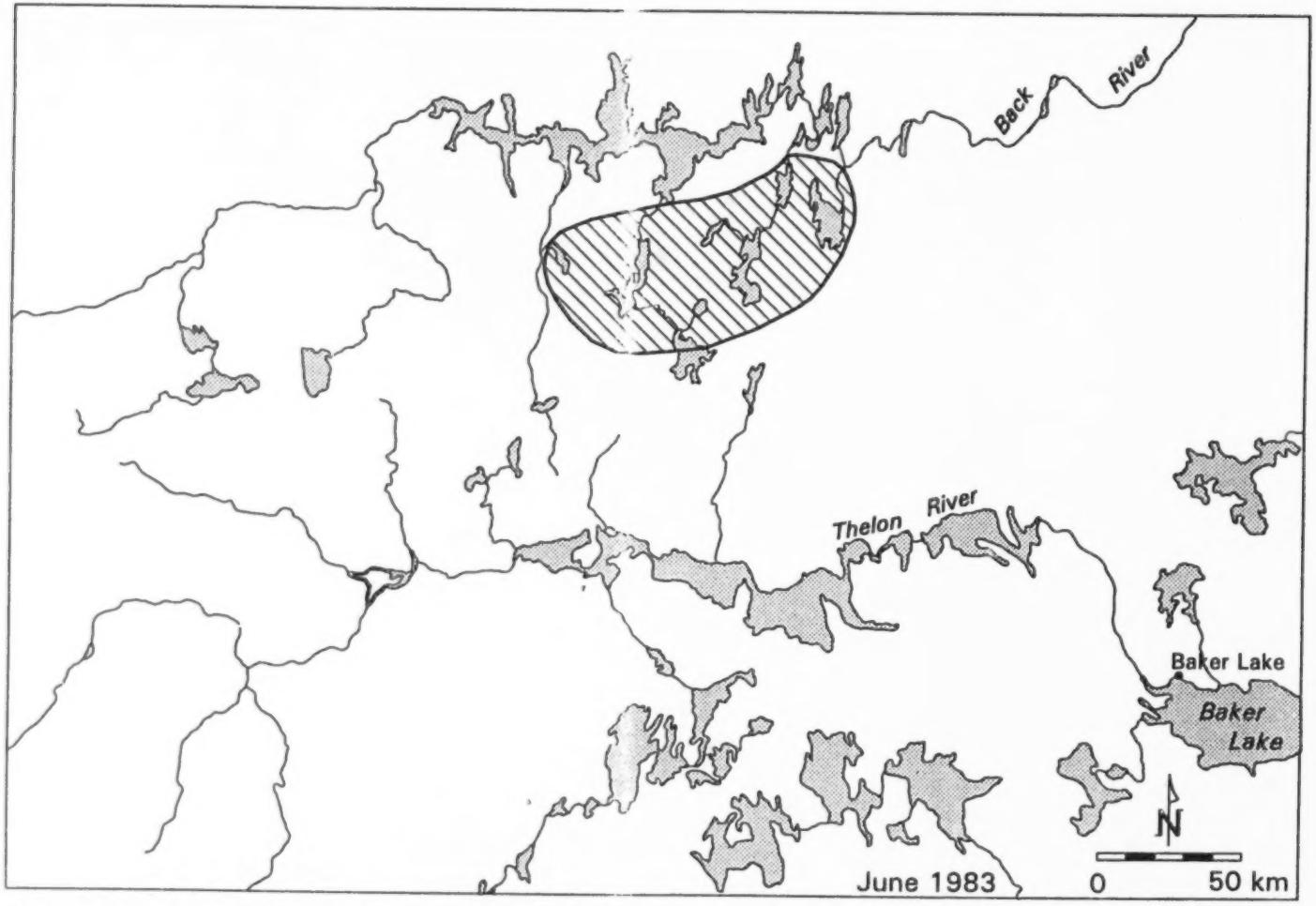

Figure 35. Distribution of cows on the Beverly calving grounds delineated during flights on 7 and 17 June 1983 (Bradley and Gates 1984).

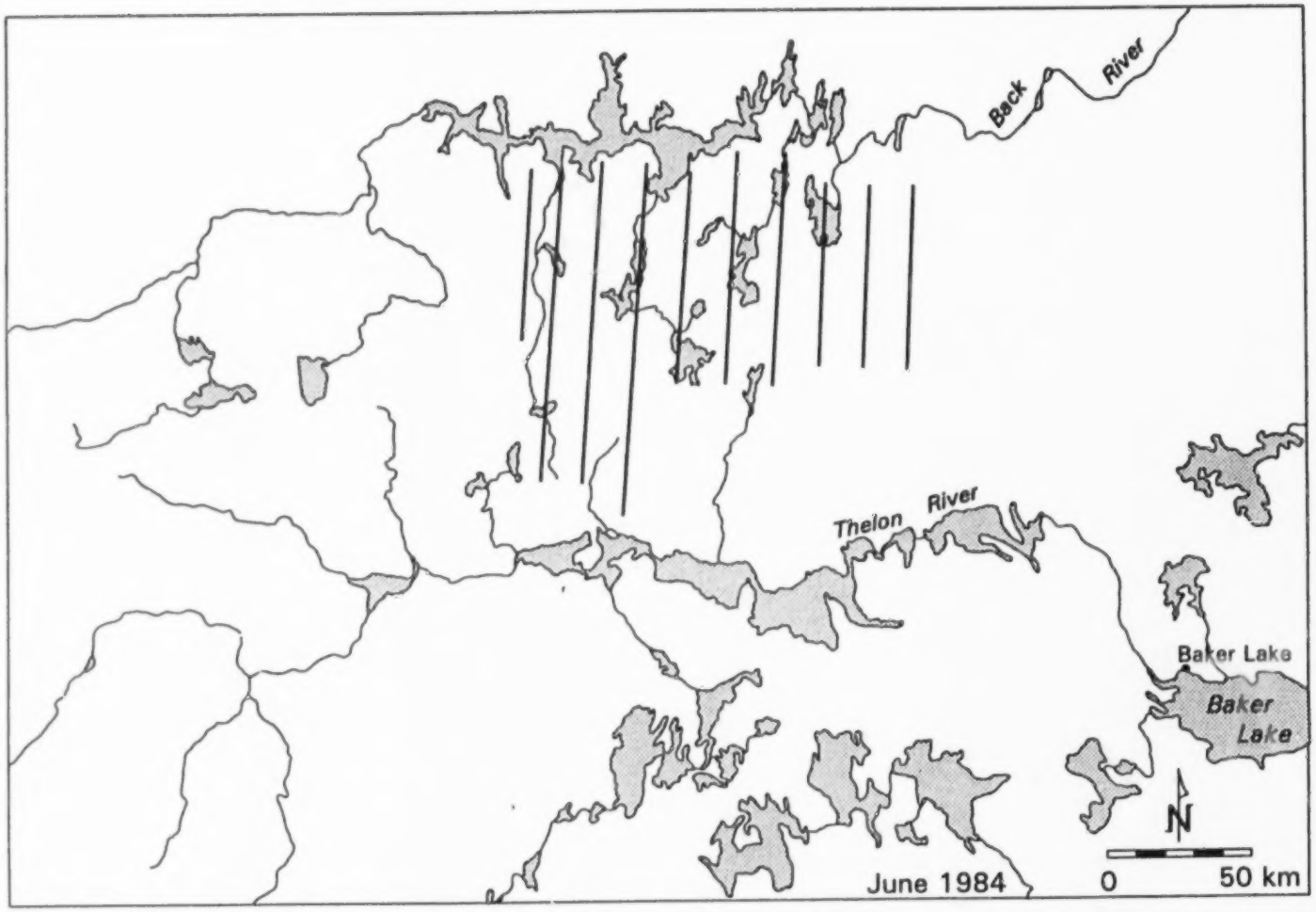

Figure 36. Beverly calving ground systematic reconnaissance flight lines, 6 June 1984.

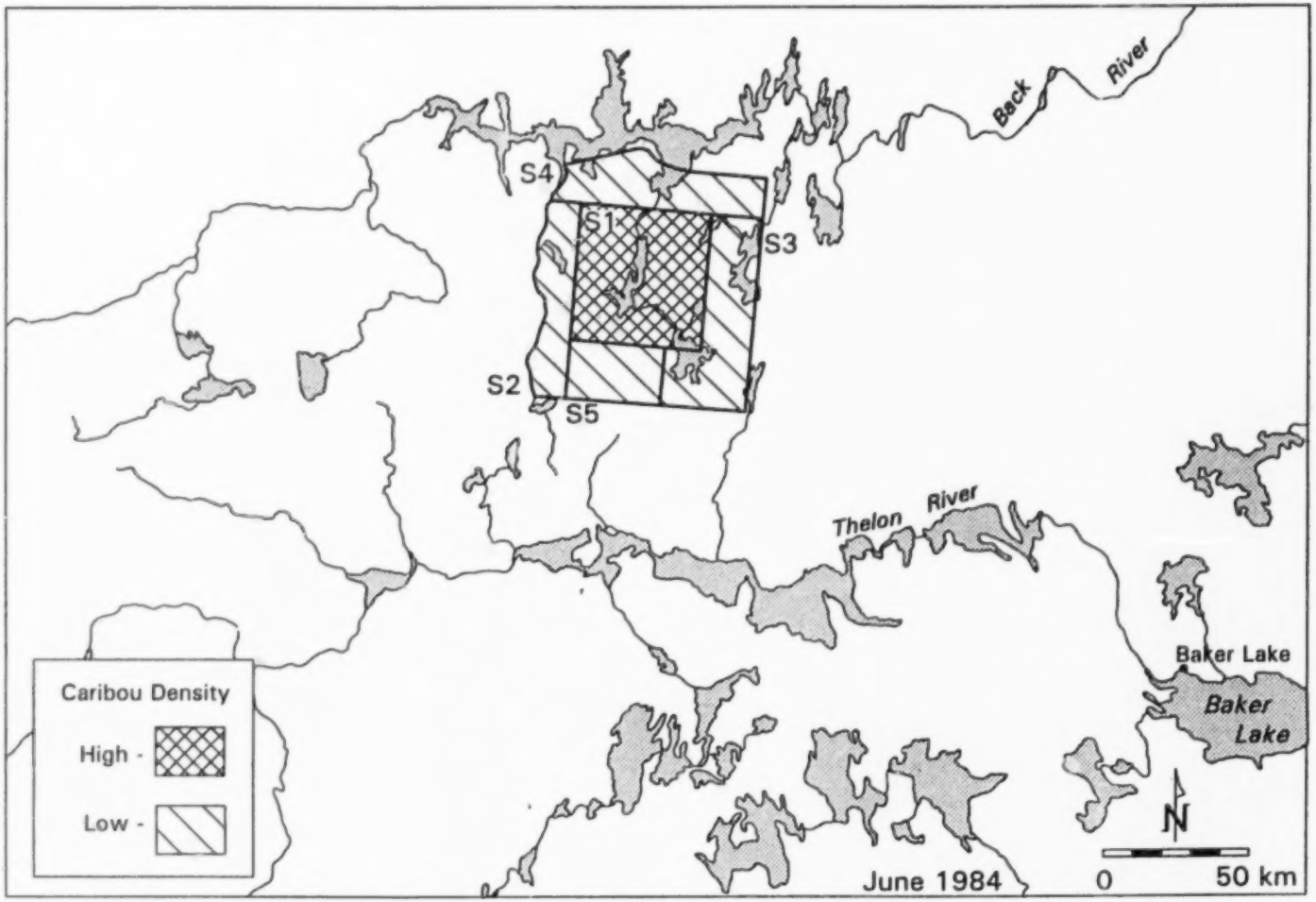

Figure 37. Beverly calving ground survey strata, 6 June 1984

Figure 38. Beverly calving ground photographic survey flight lines, 12-13 June 1984

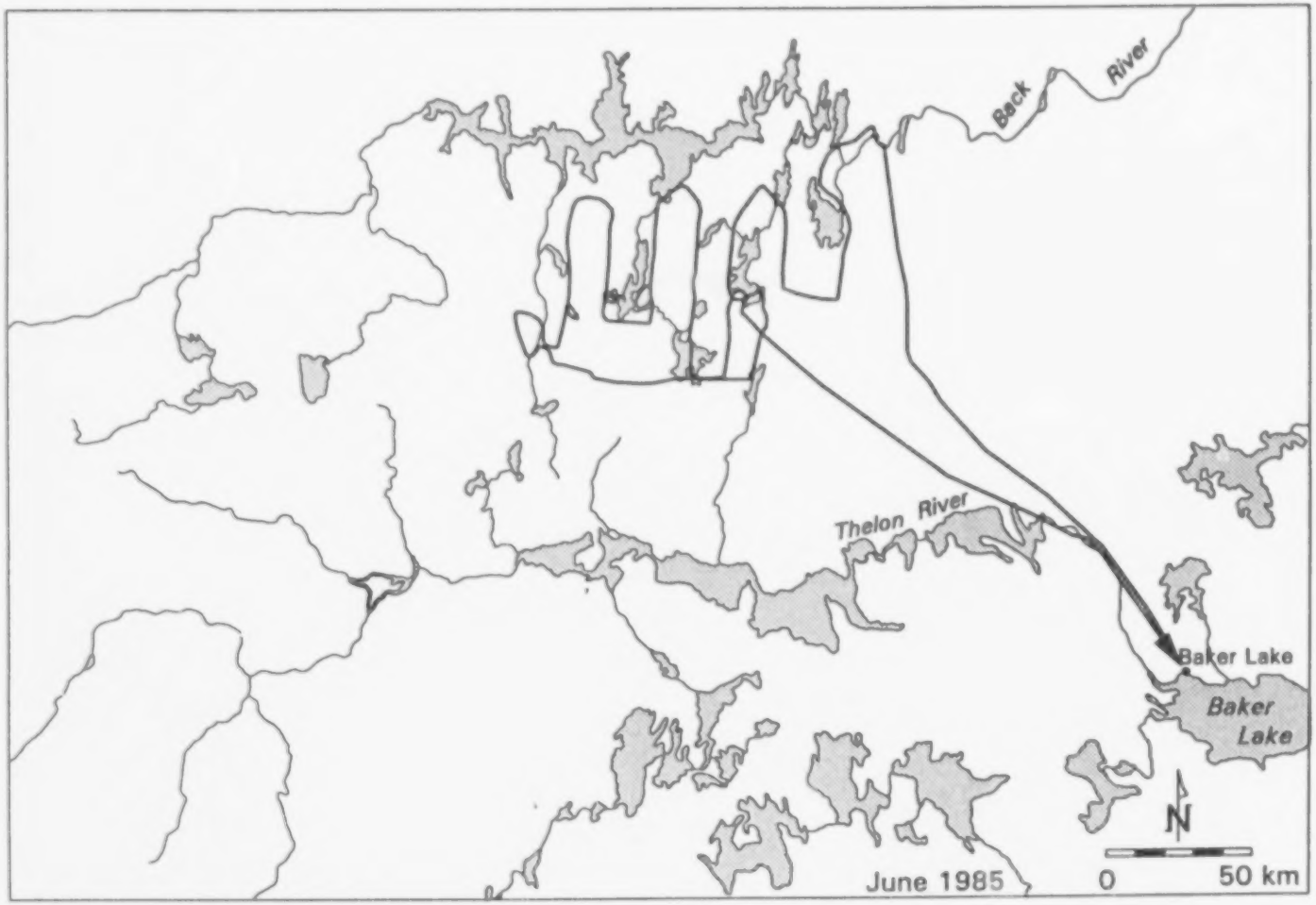

Figure 39. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 8 June 1985

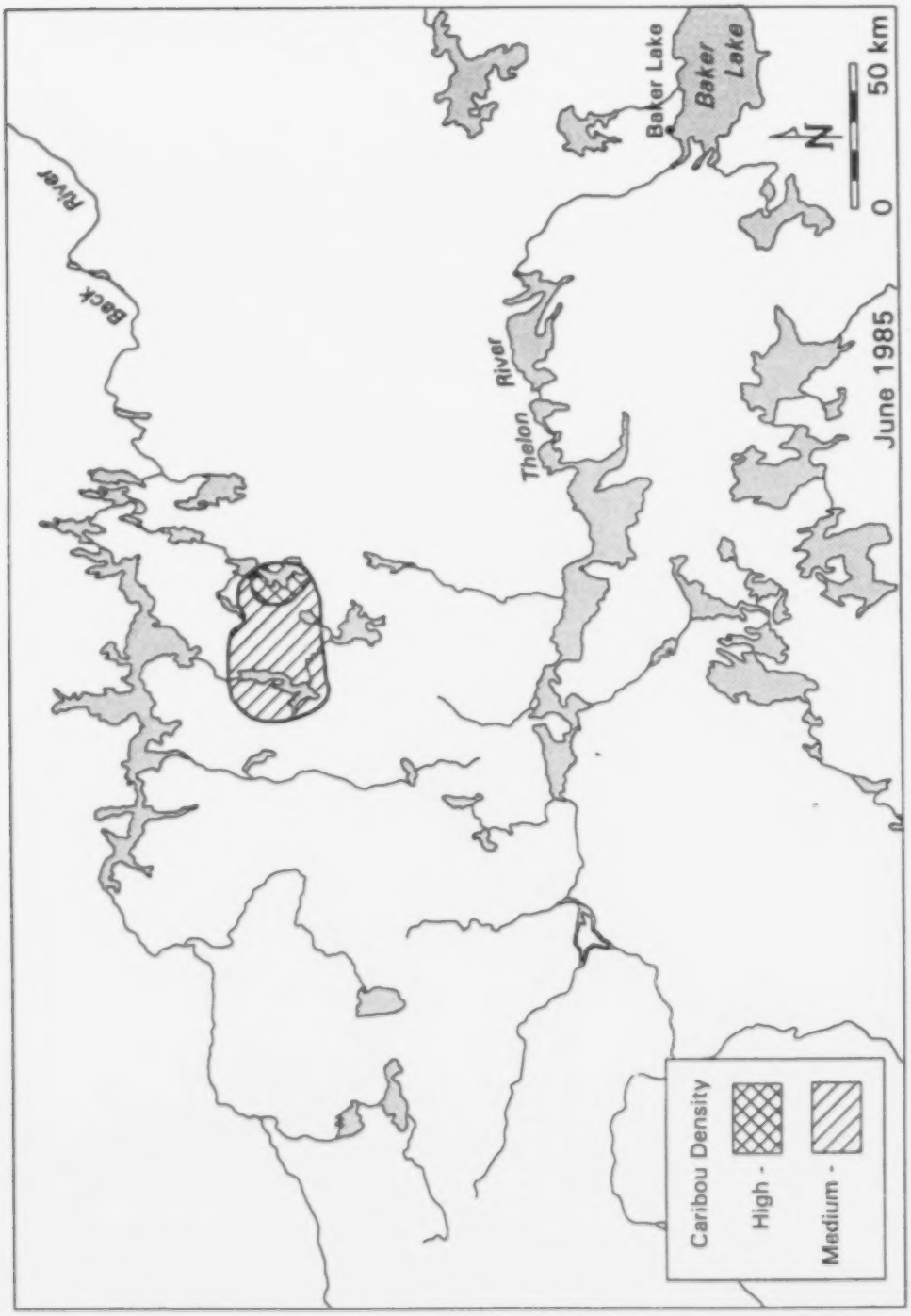

Figure 40. Distribution of cows on the Beverly calving grounds, 8 June 1985 (Duquette 1985, RWED files)

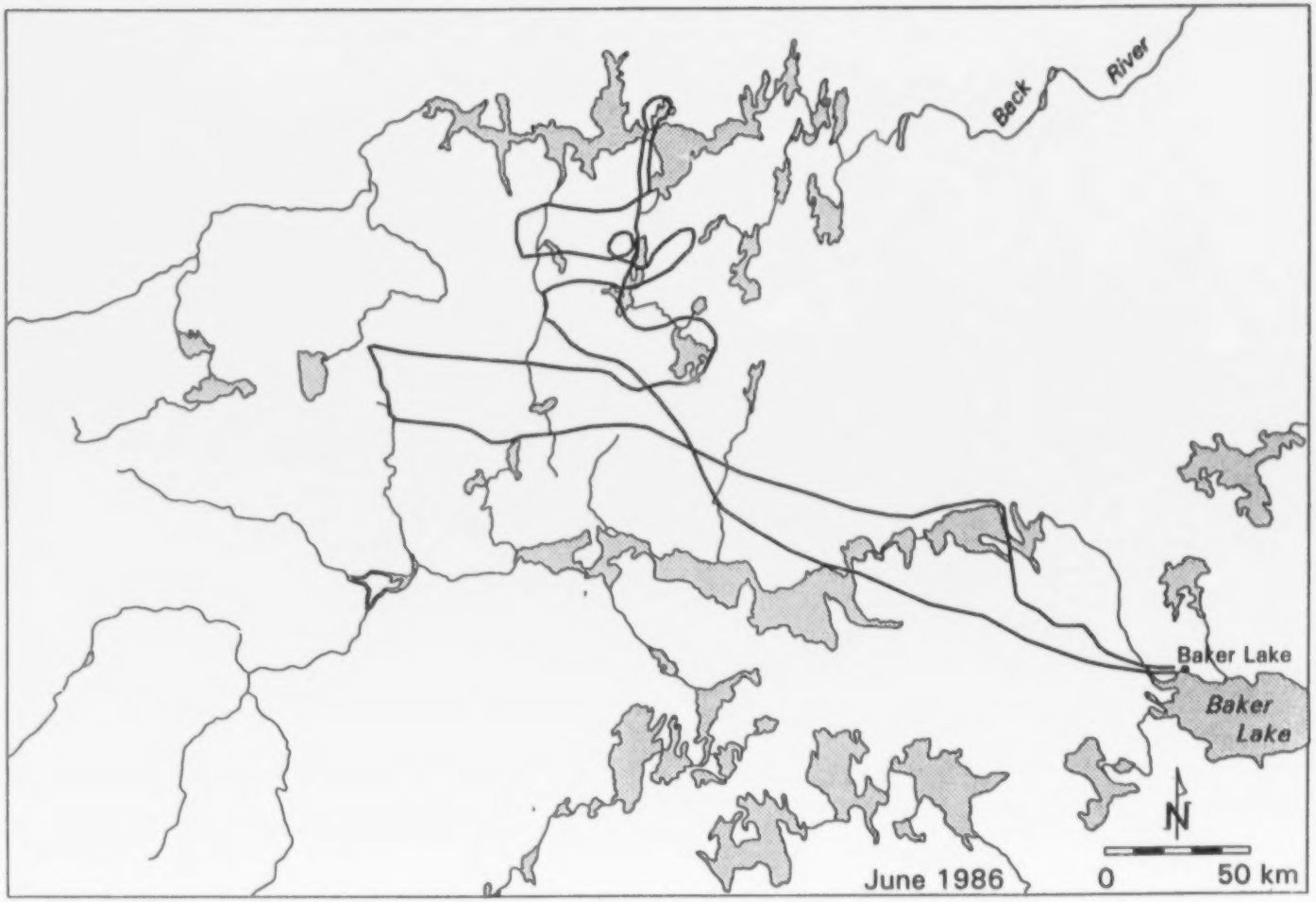

Figure 41. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 10 June 1986 (Liepins 1986).

Figure 42. Distribution of cows on the Beverly calving grounds, 10 June 1986 (Liepins 1986).

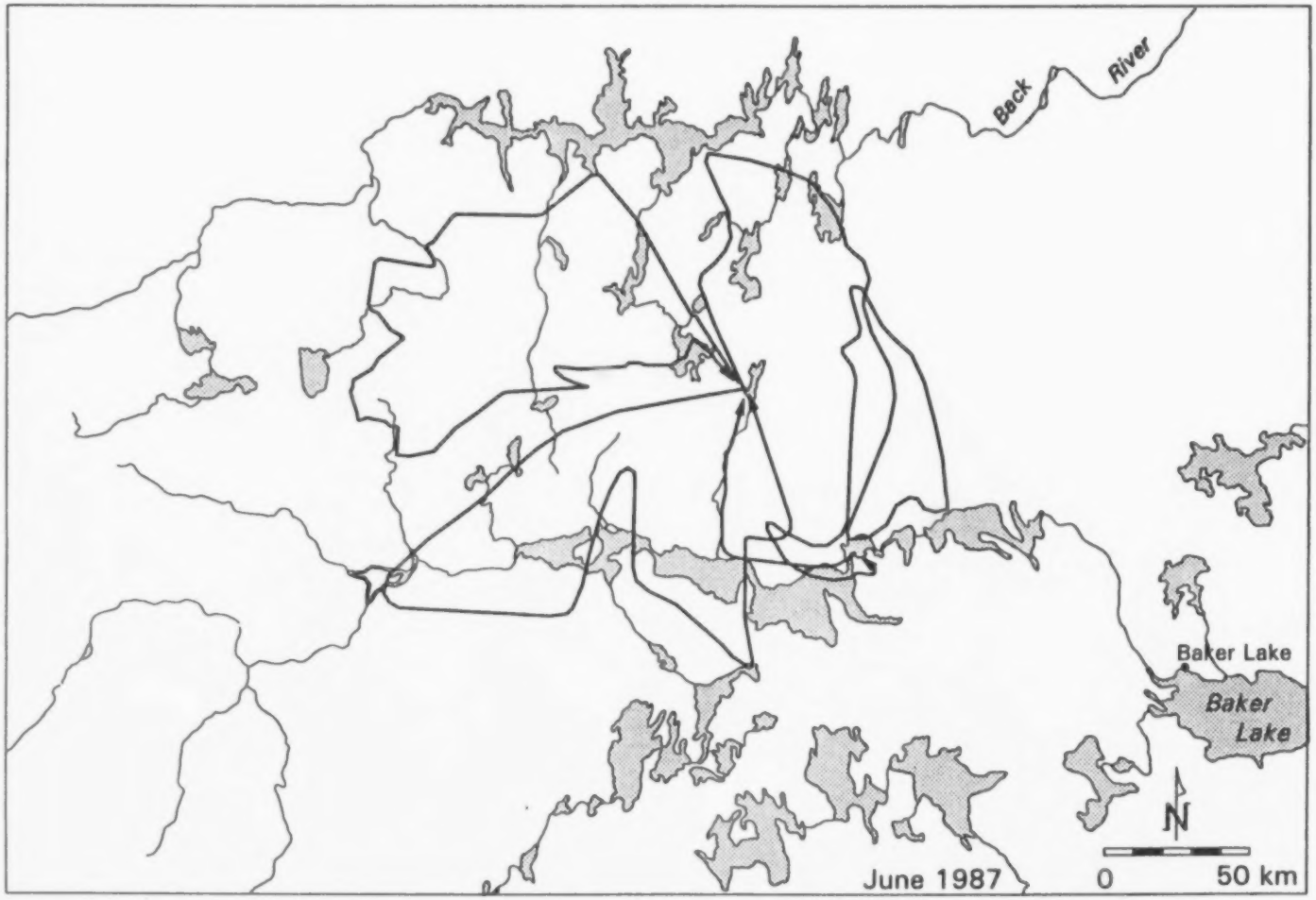

Figure 43. Beverly calving ground unsystematic reconnaissance flight lines, 3 June 1987

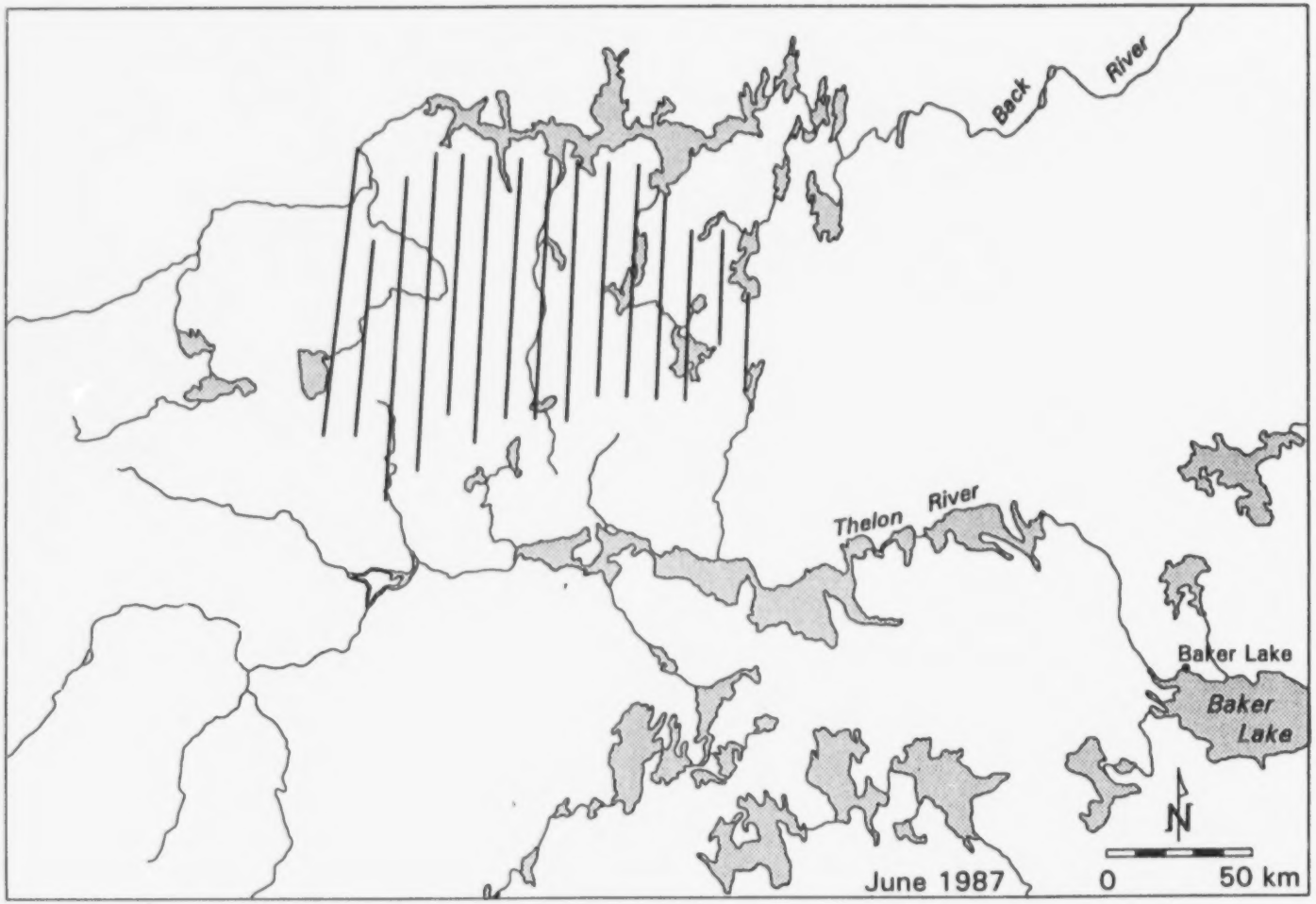

Figure 44. Beverly calving ground systematic reconnaissance flight lines, 7 June 1987

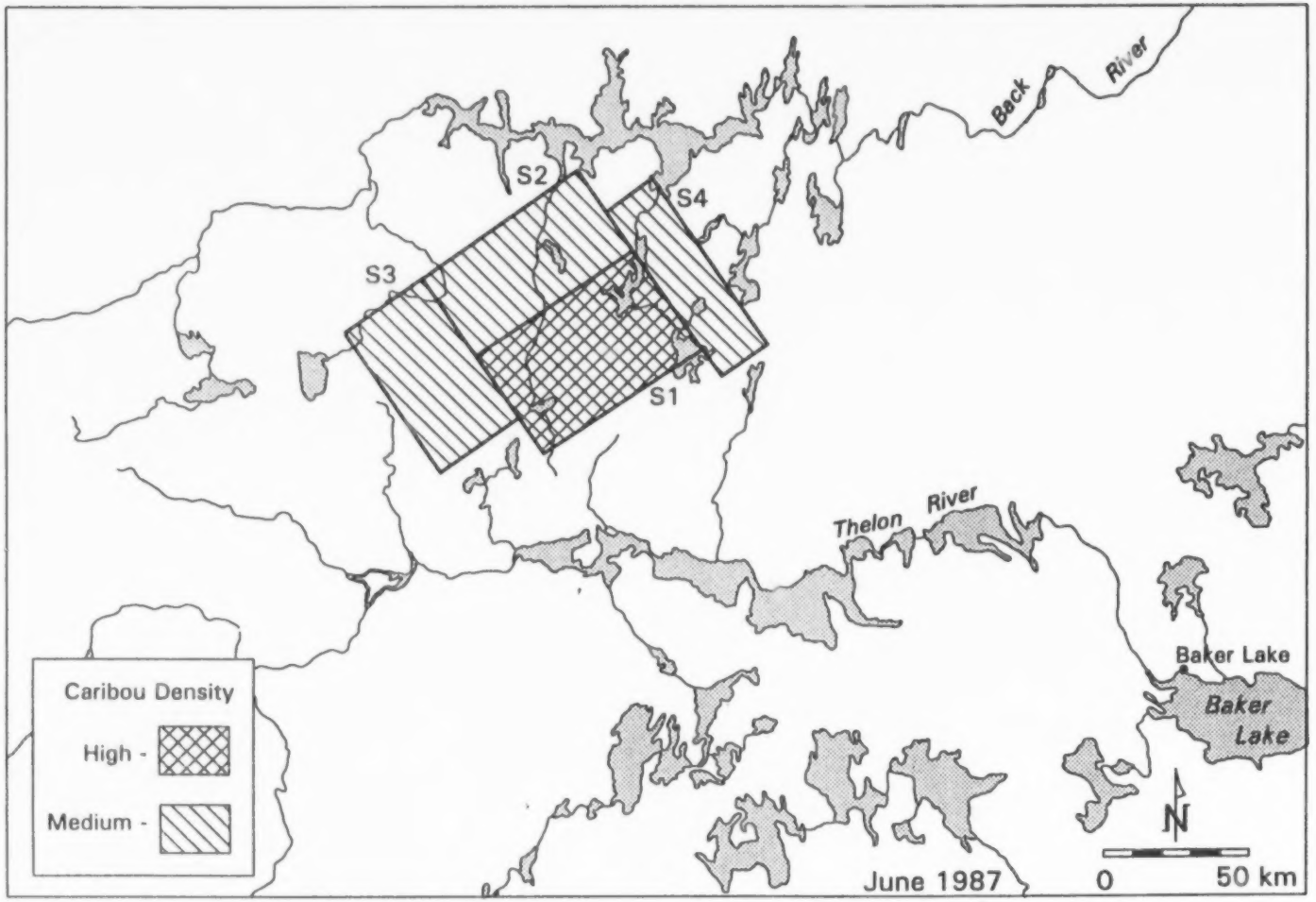

Figure 45. Beverly calving ground survey strata, 7 June 1987

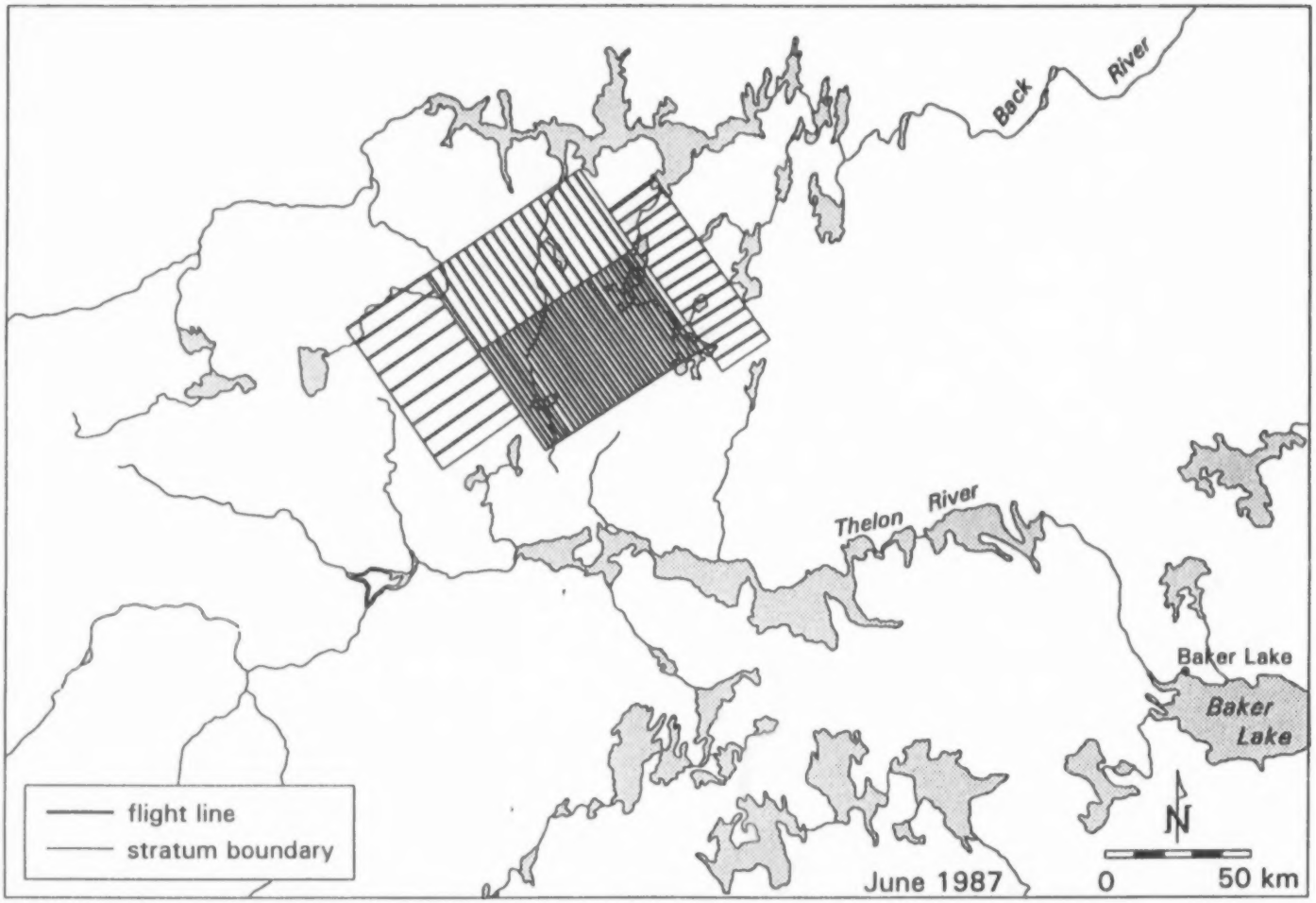

Figure 46. Beverly calving ground stratified transect survey flight lines, 8-9 June 1987

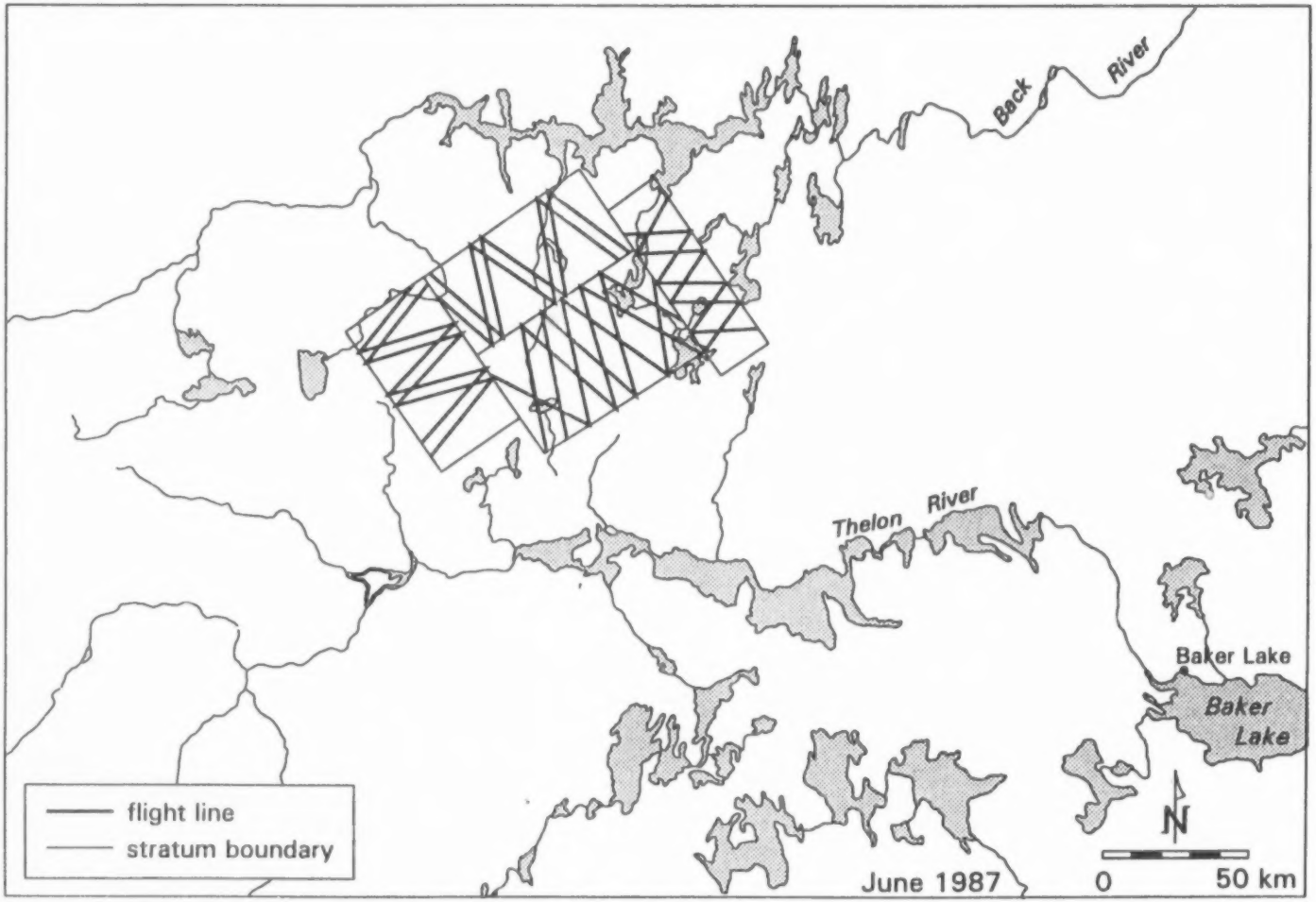

Figure 47. Beverly calving ground composition survey flight lines, 9-10 June 1987

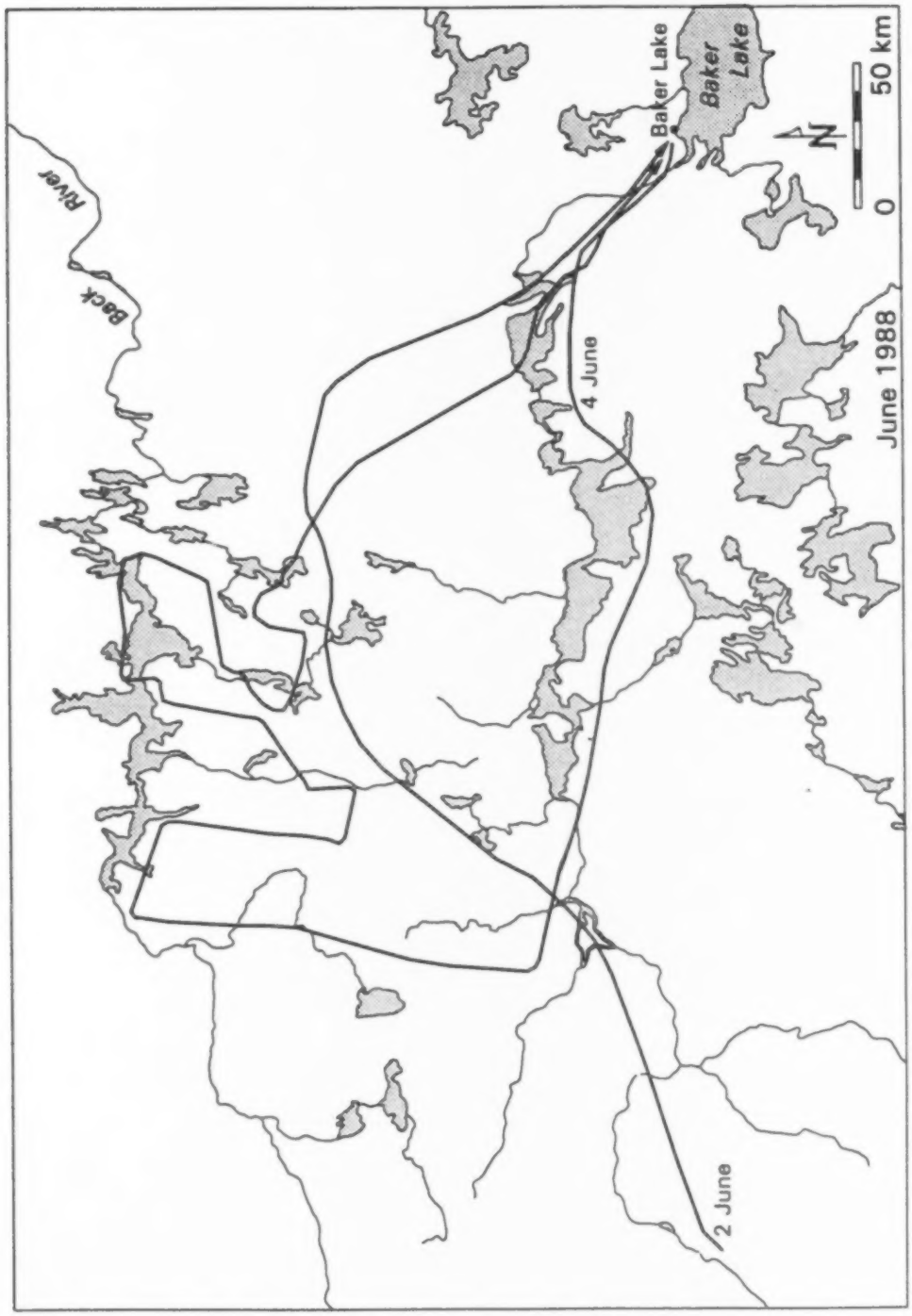

Figure 48. Beverly calving ground unsystematic reconnaissance flight lines, 2-4 June 1988

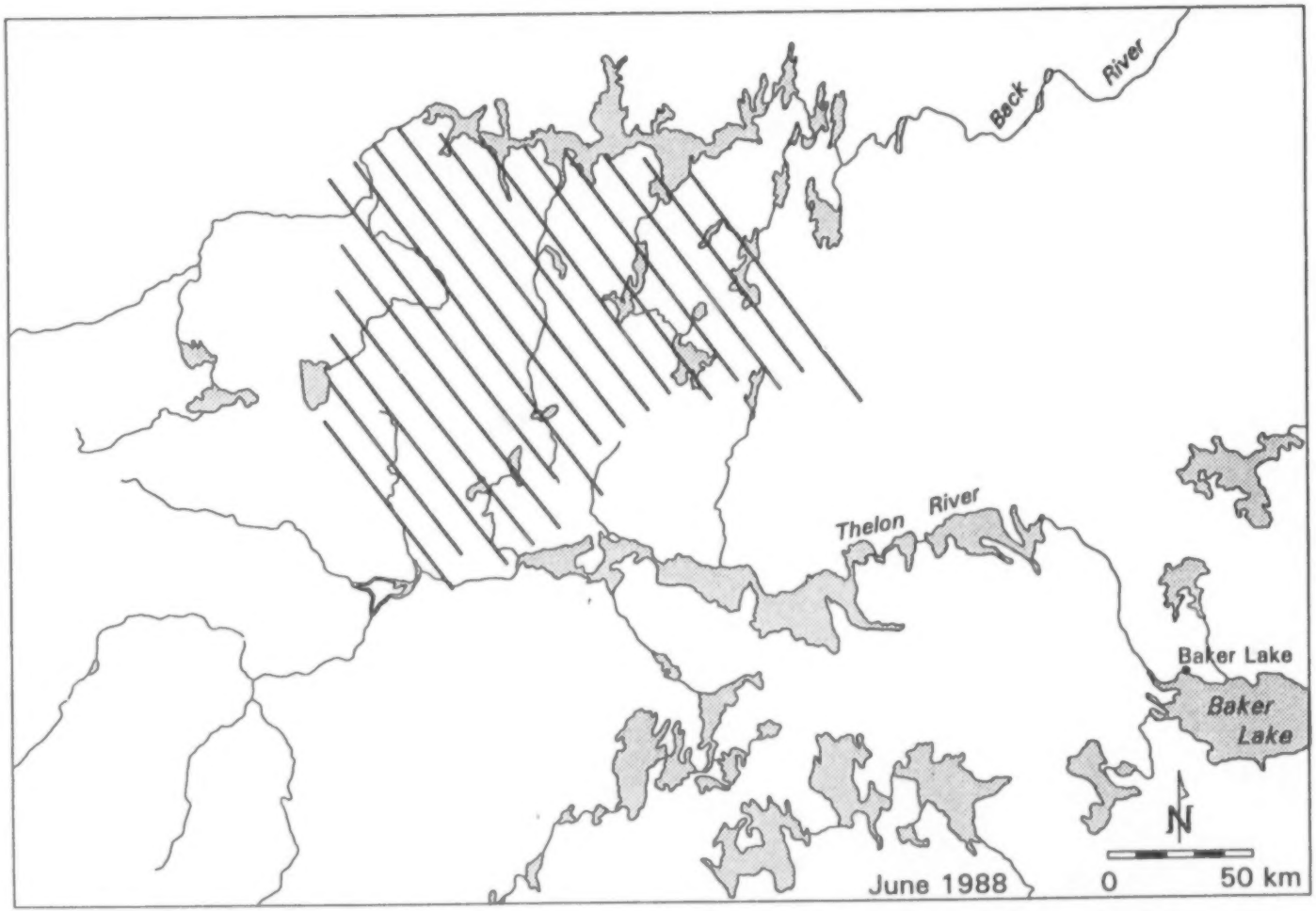

Figure 49. Beverly calving ground systematic reconnaissance flight lines, 5-6 June 1988

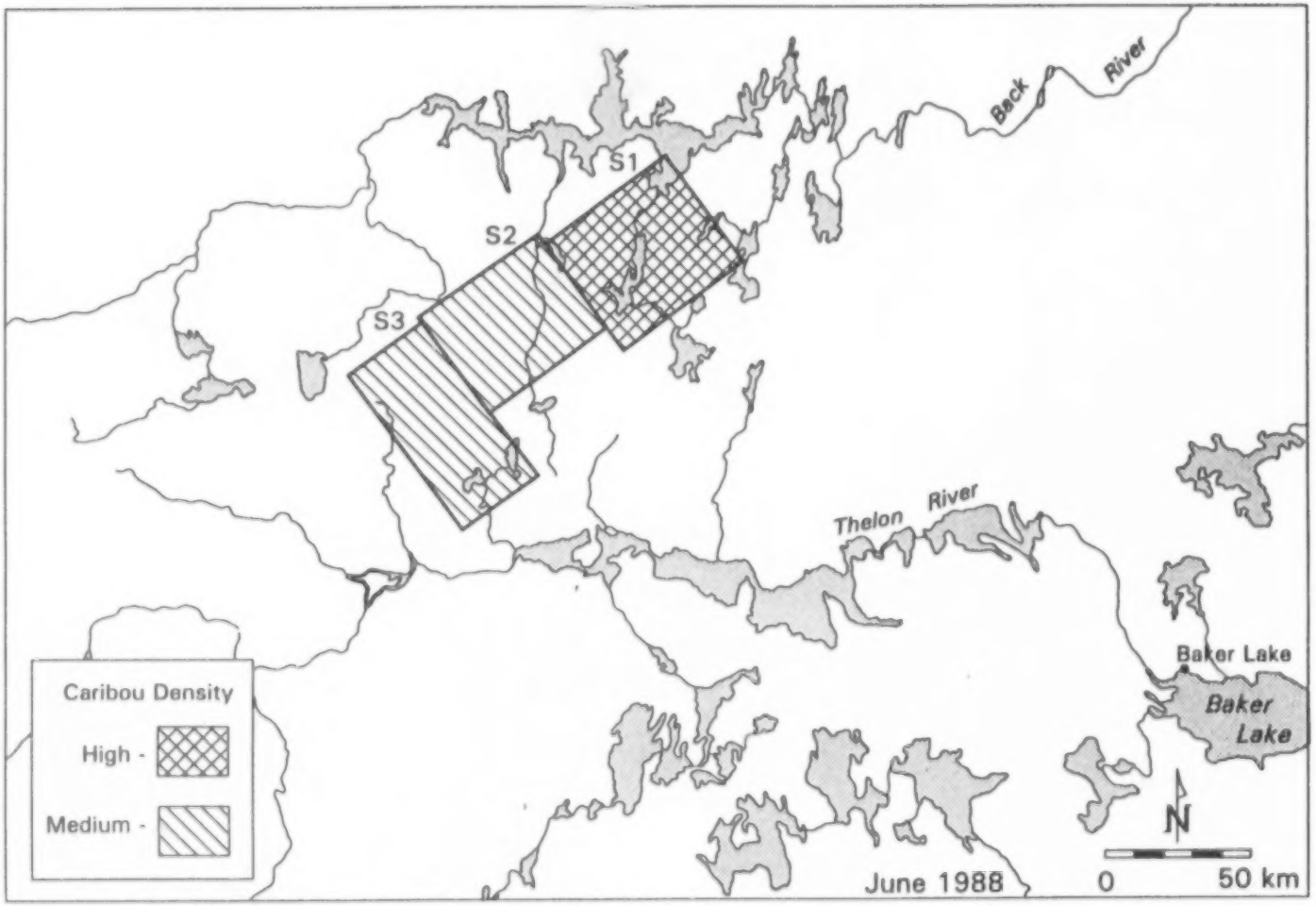

Figure 50. Beverly calving ground survey strata, 5-6 June 1988

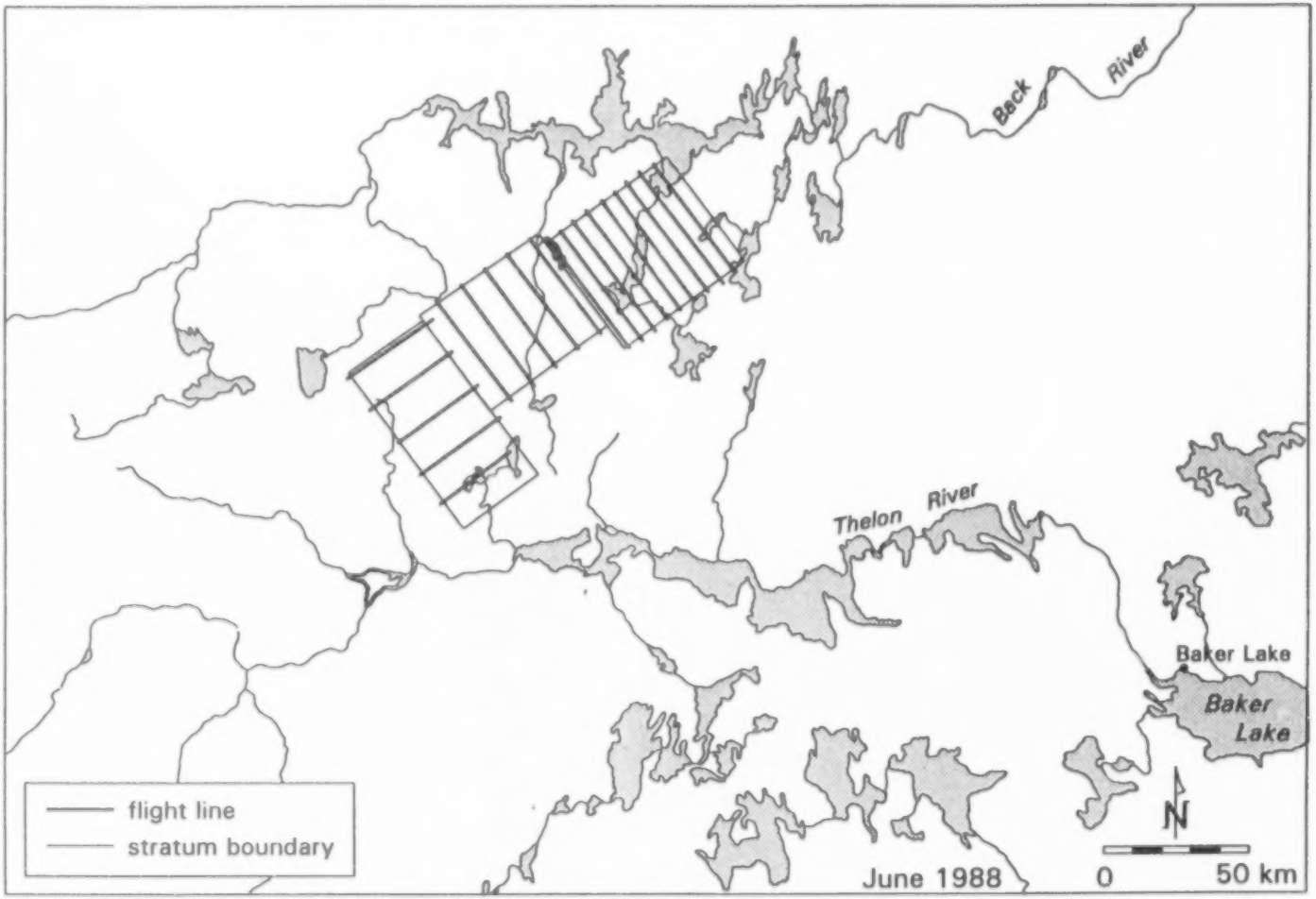

Figure 51. Beverly calving ground photographic survey flight lines, 8-12 June 1988

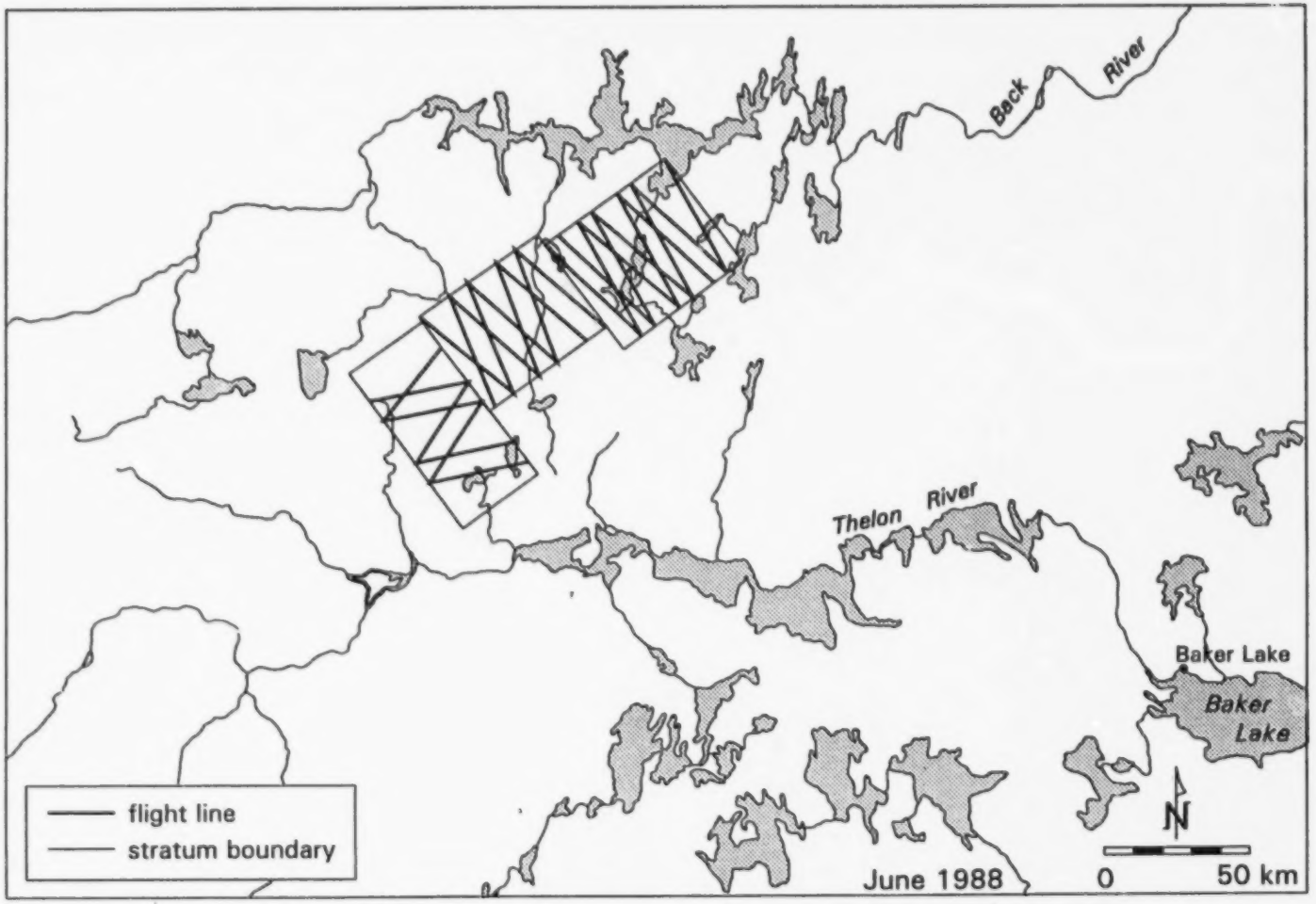

Figure 52. Beverly calving ground composition survey flight lines, 8-14 June 1988

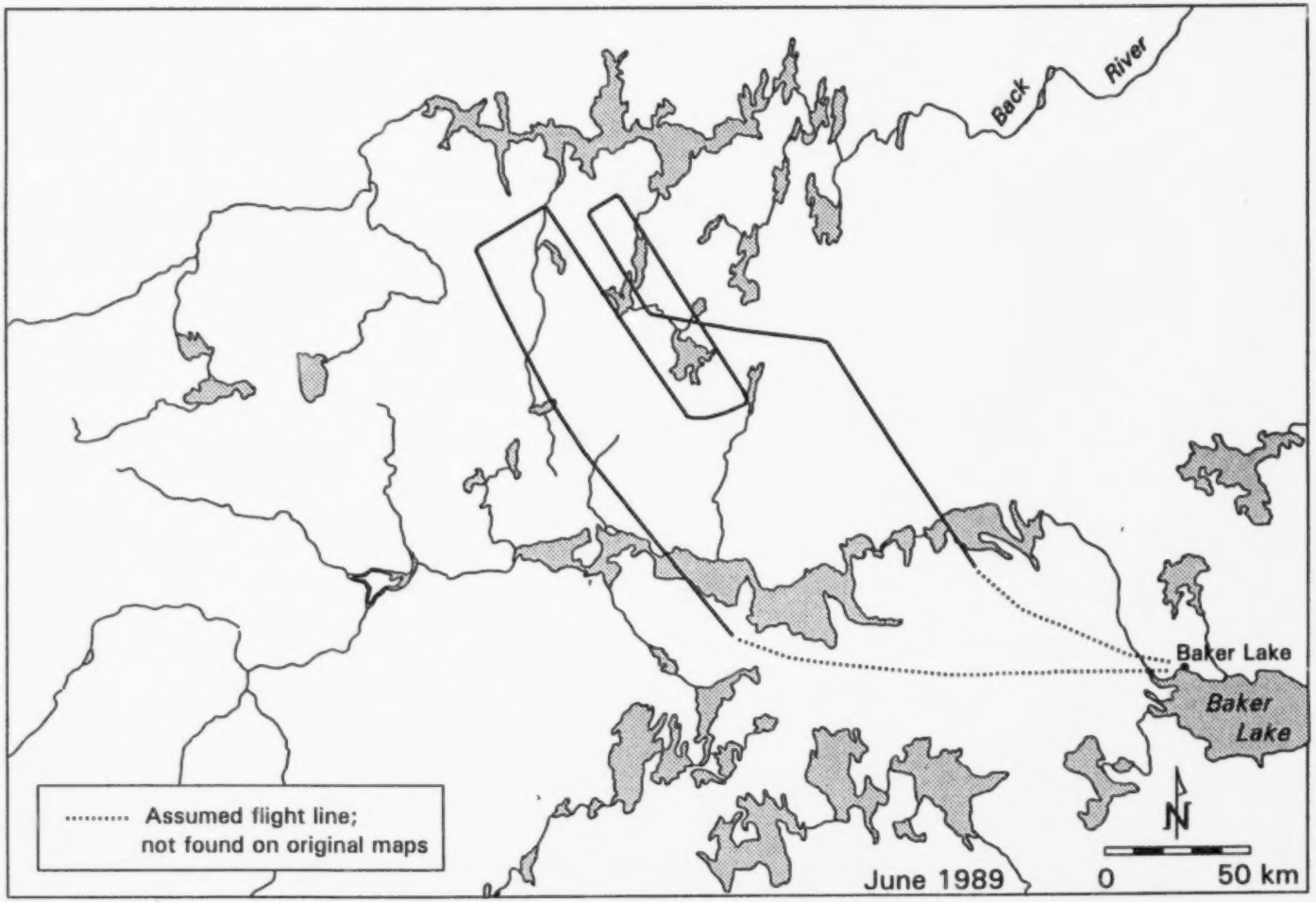

Figure 53. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 10 June 1989 (Chalmers 1989).

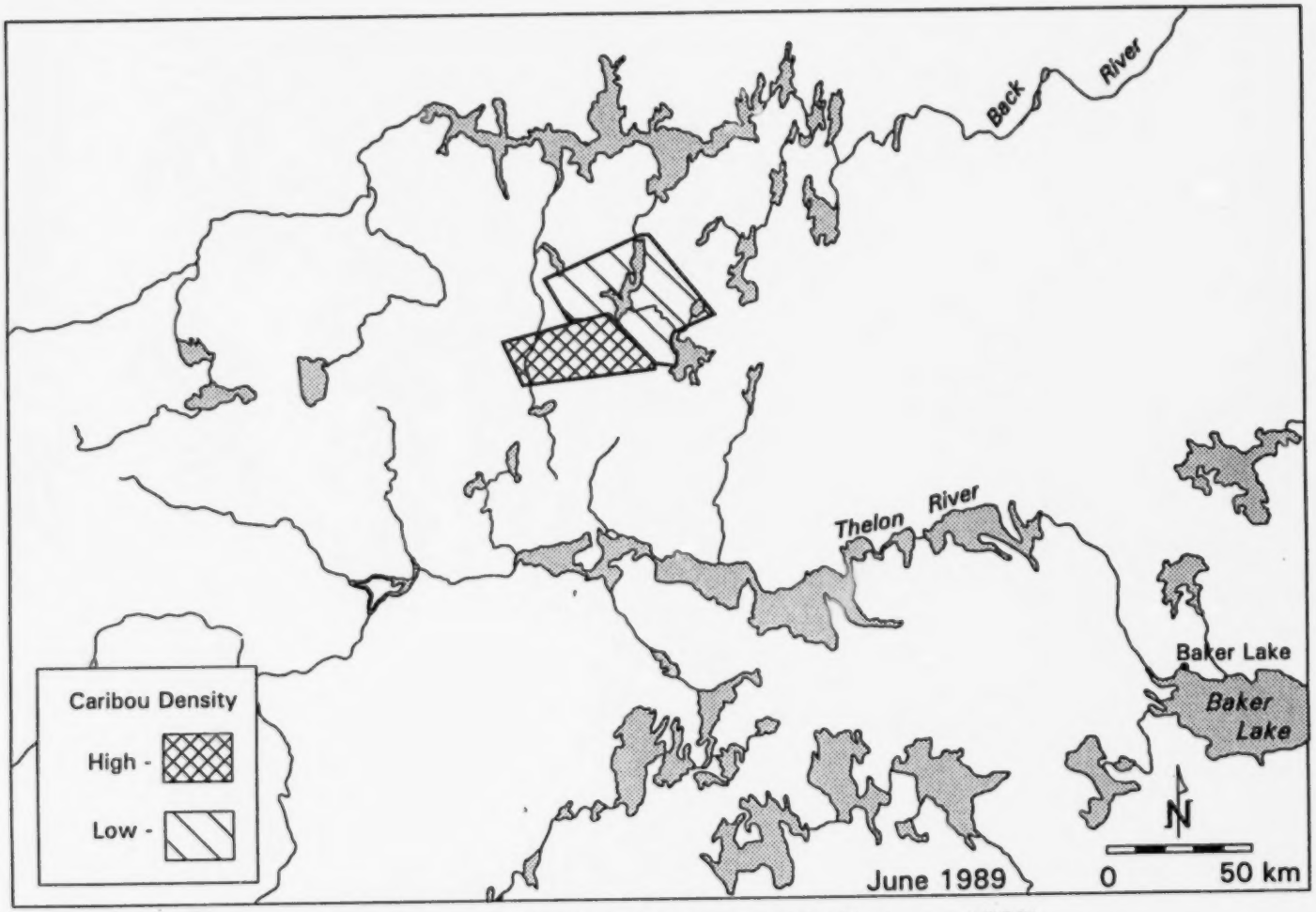

Figure 54. Beverly caribou calving distribution, 10 June 1989 (Chalmers 1989).

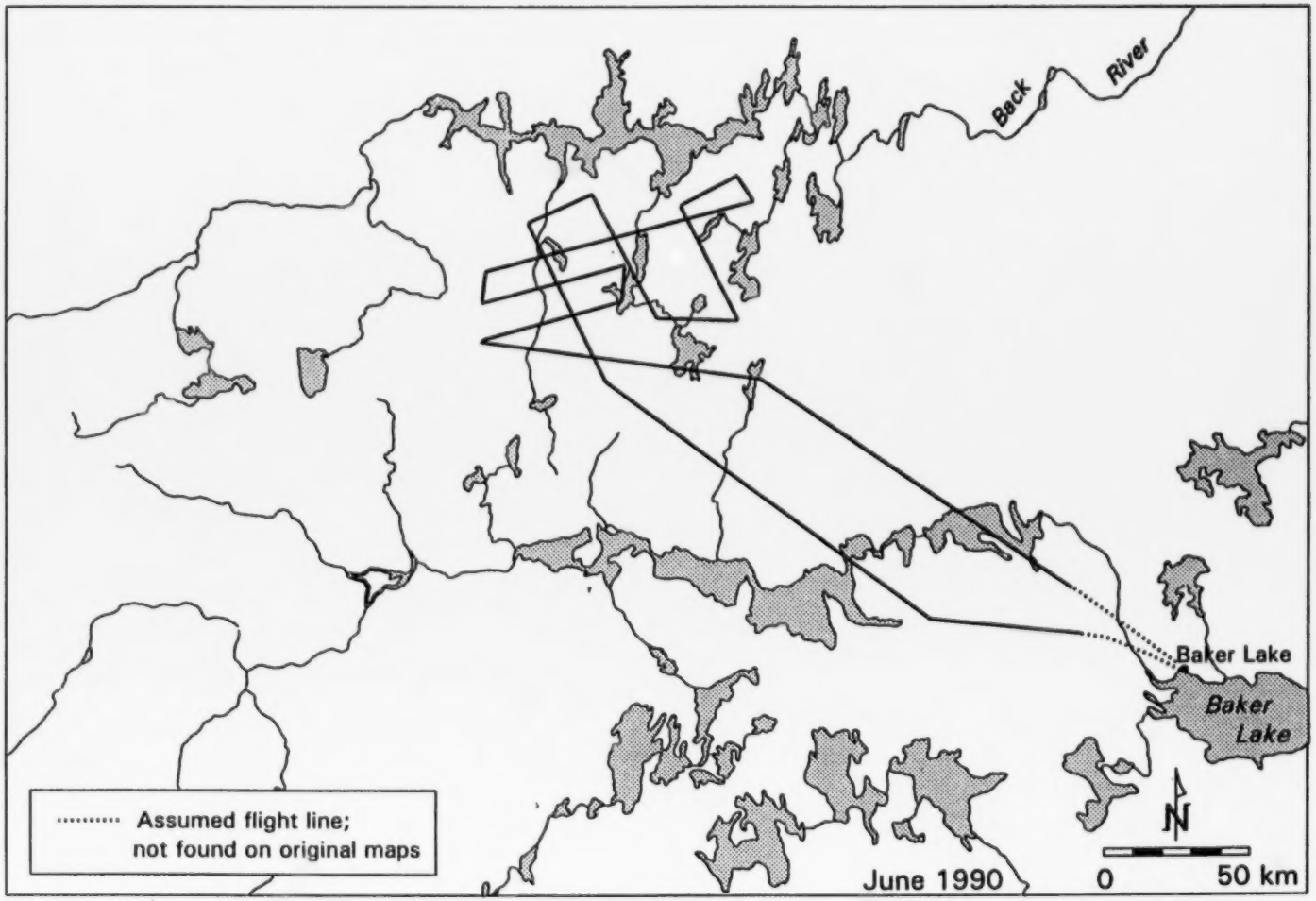

Figure 55. Lines flown during the caribou monitoring program to delineate the Beverly calving grounds, 10 June 1990 (Gauthier and Mulders 1990).

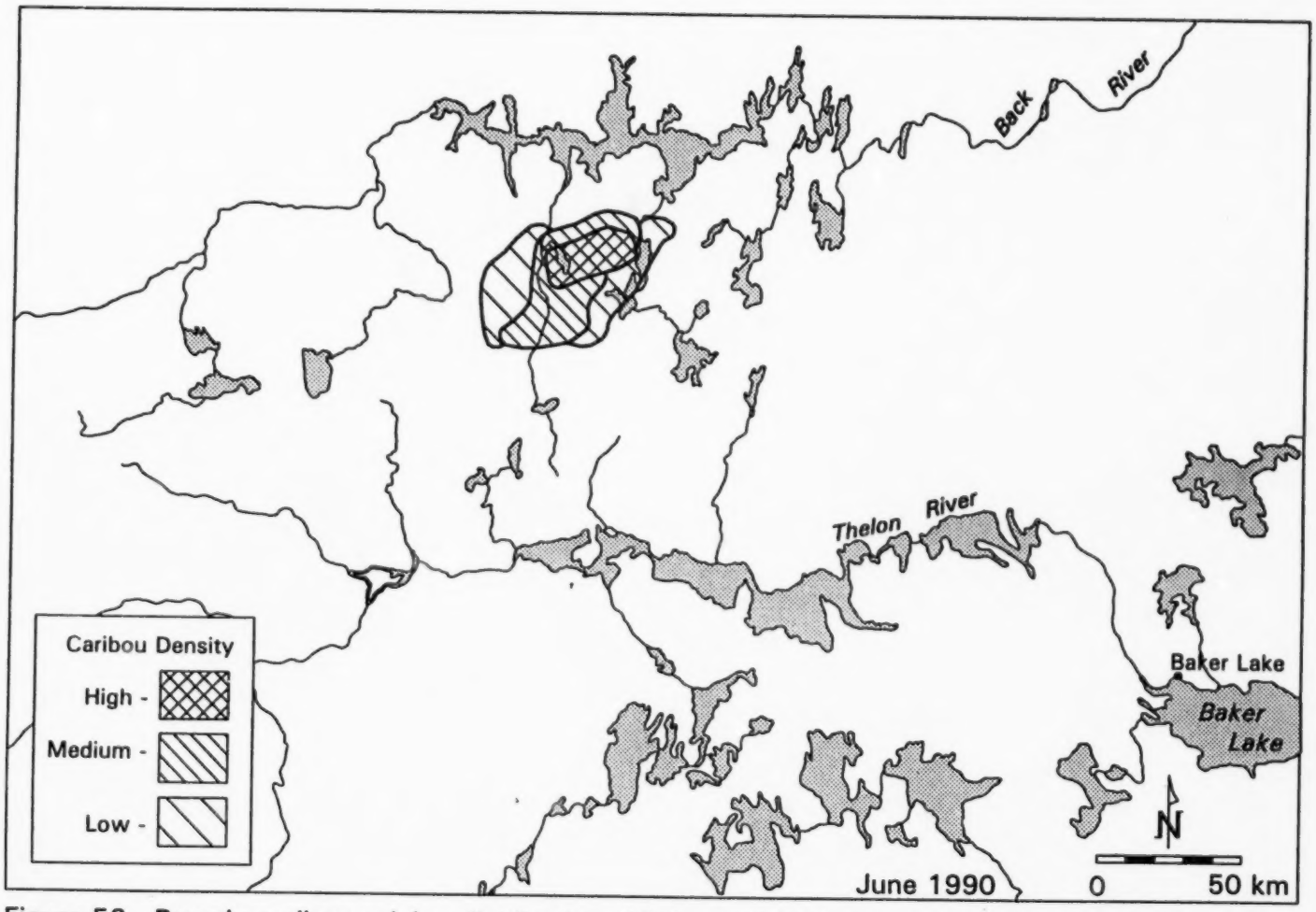

Figure 56. Beverly caribou calving distribution, 10 June 1990 (Gauthier and Mulders 1990)

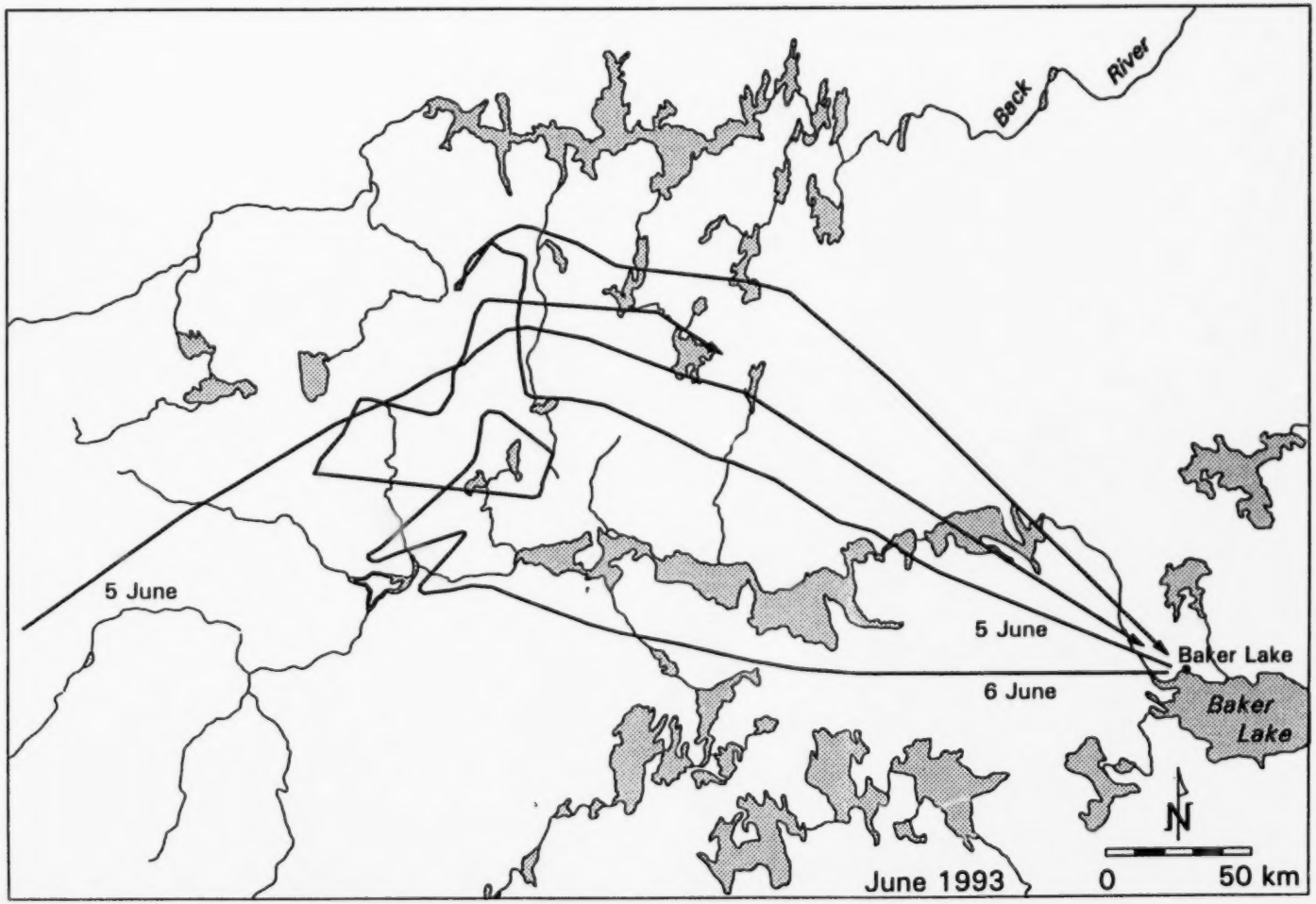

Figure 57. Beverly calving ground unsystematic reconnaissance flight lines, 5-6 June 1993

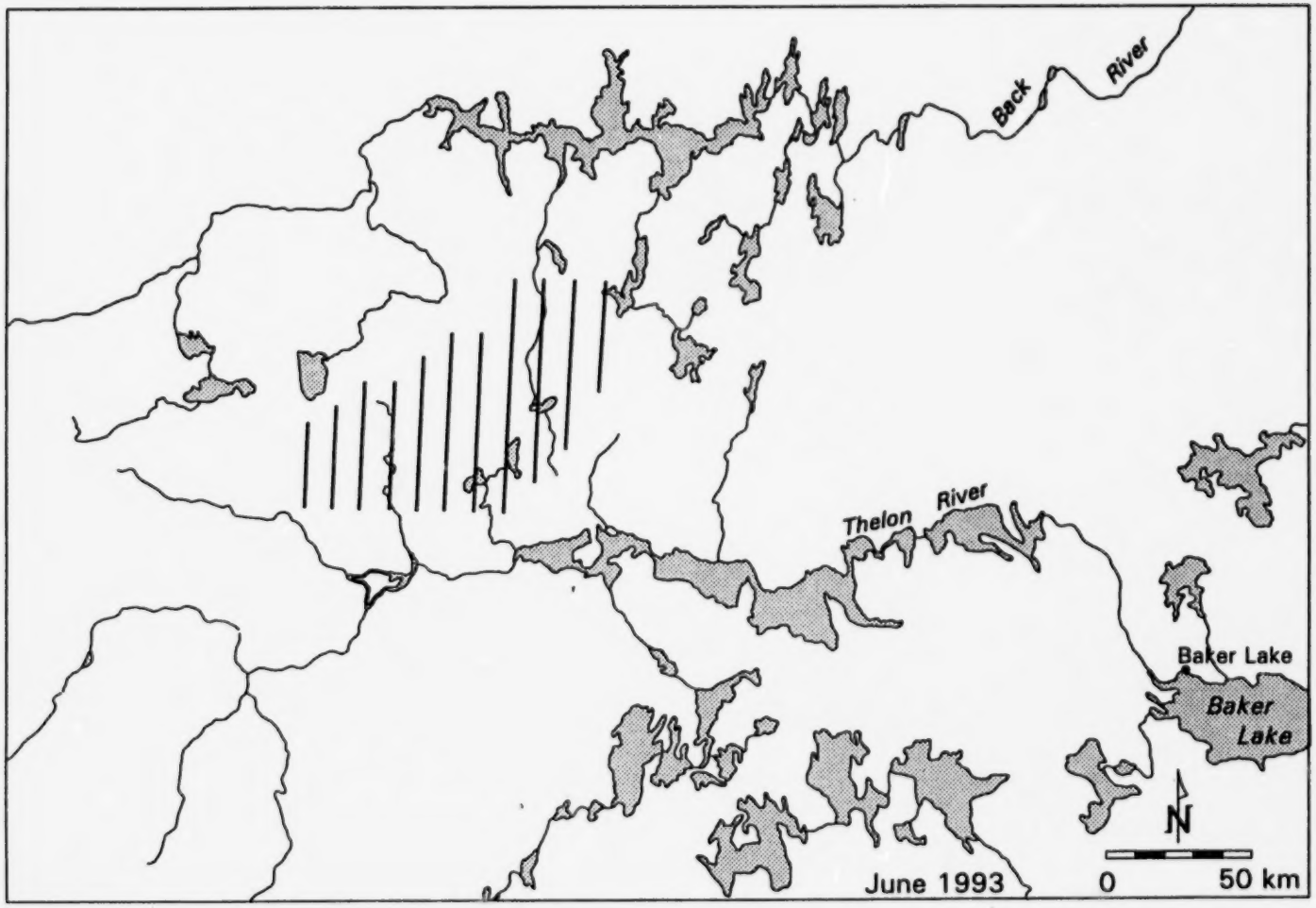

Figure 58. Beverly calving ground systematic reconnaissance flight lines, 6 June 1993

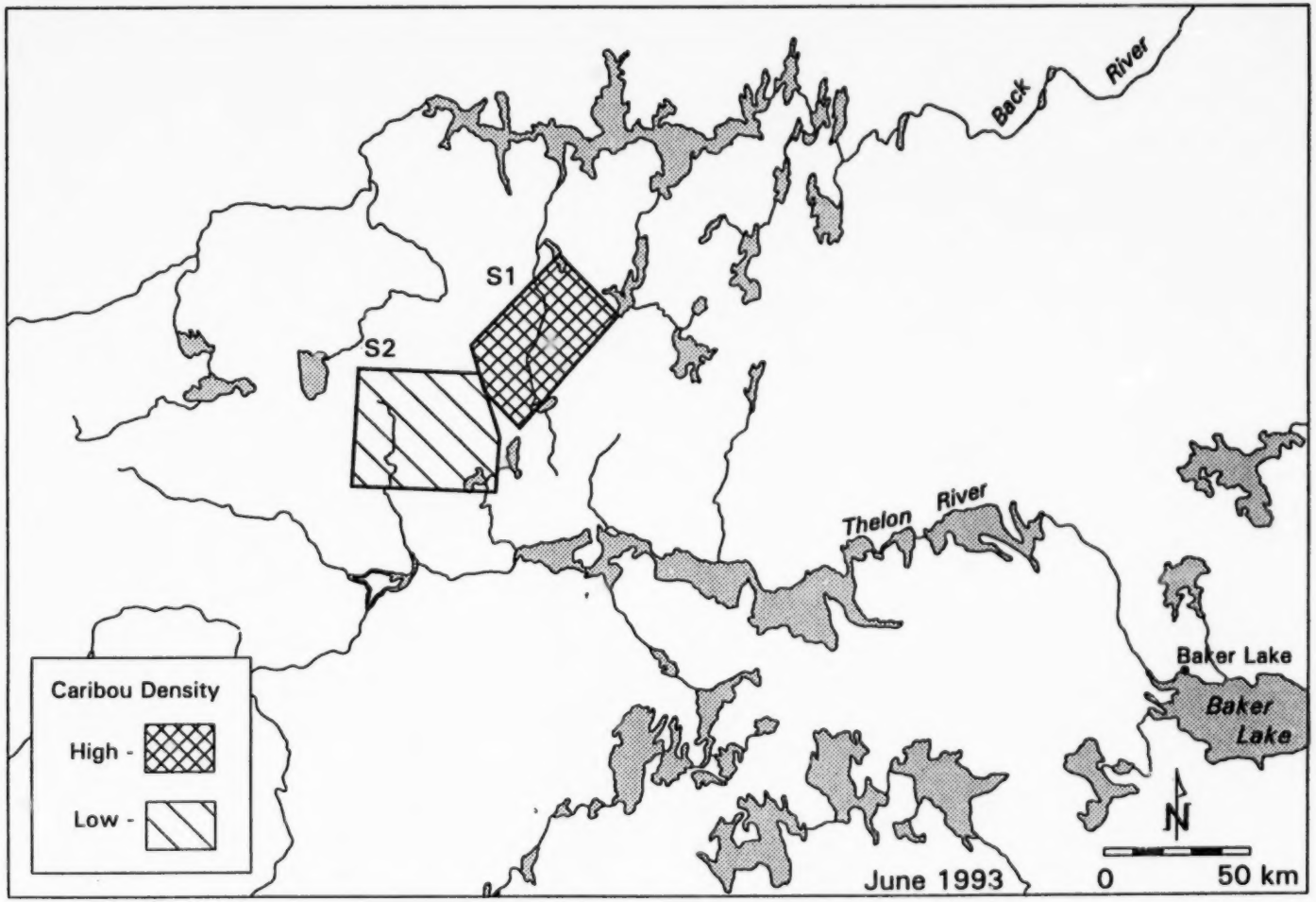

Figure 59. Beverly calving ground survey strata, 6 June 1993

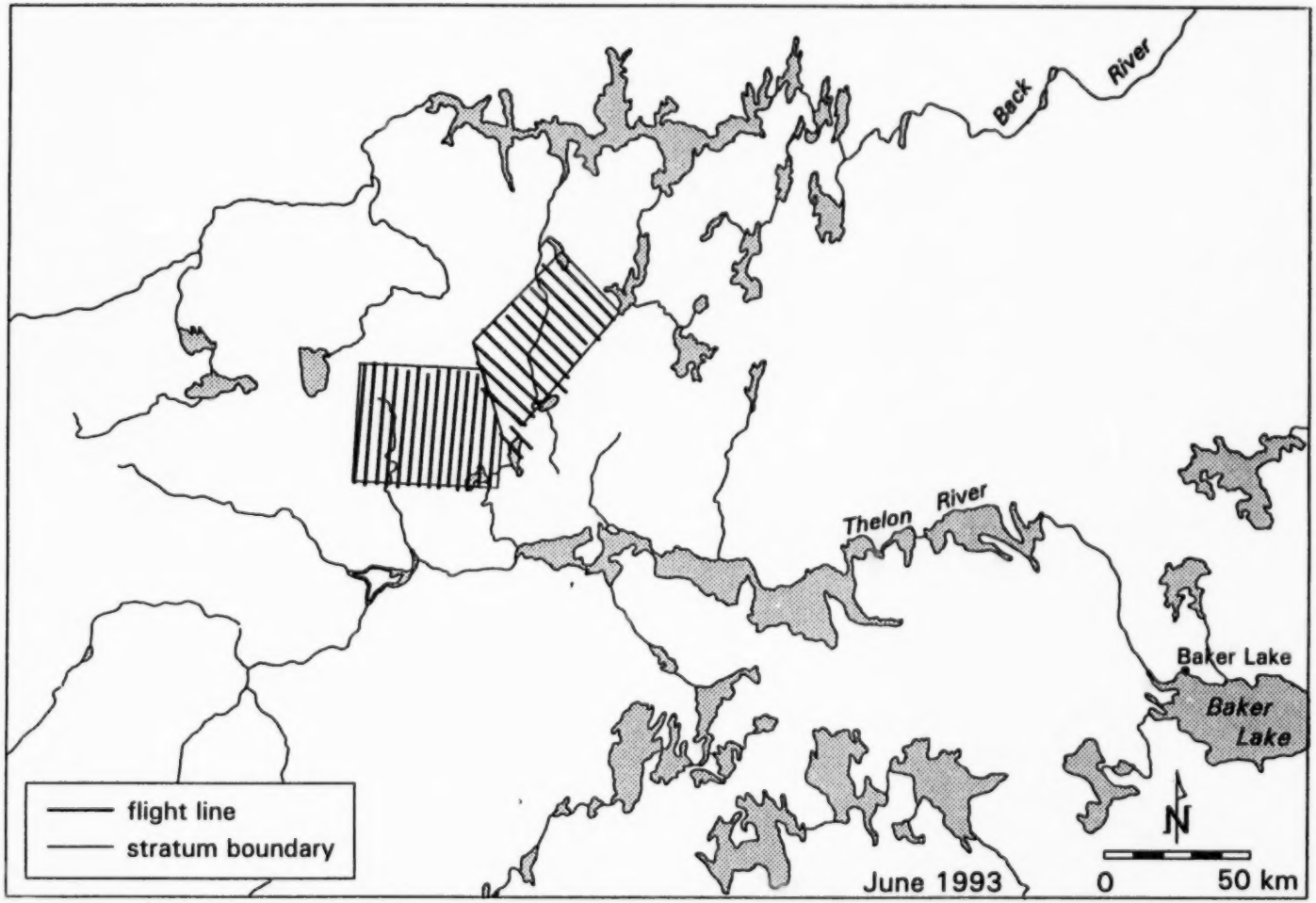

Figure 60. Beverly calving ground photographic survey flight lines, 11-12 June 1993

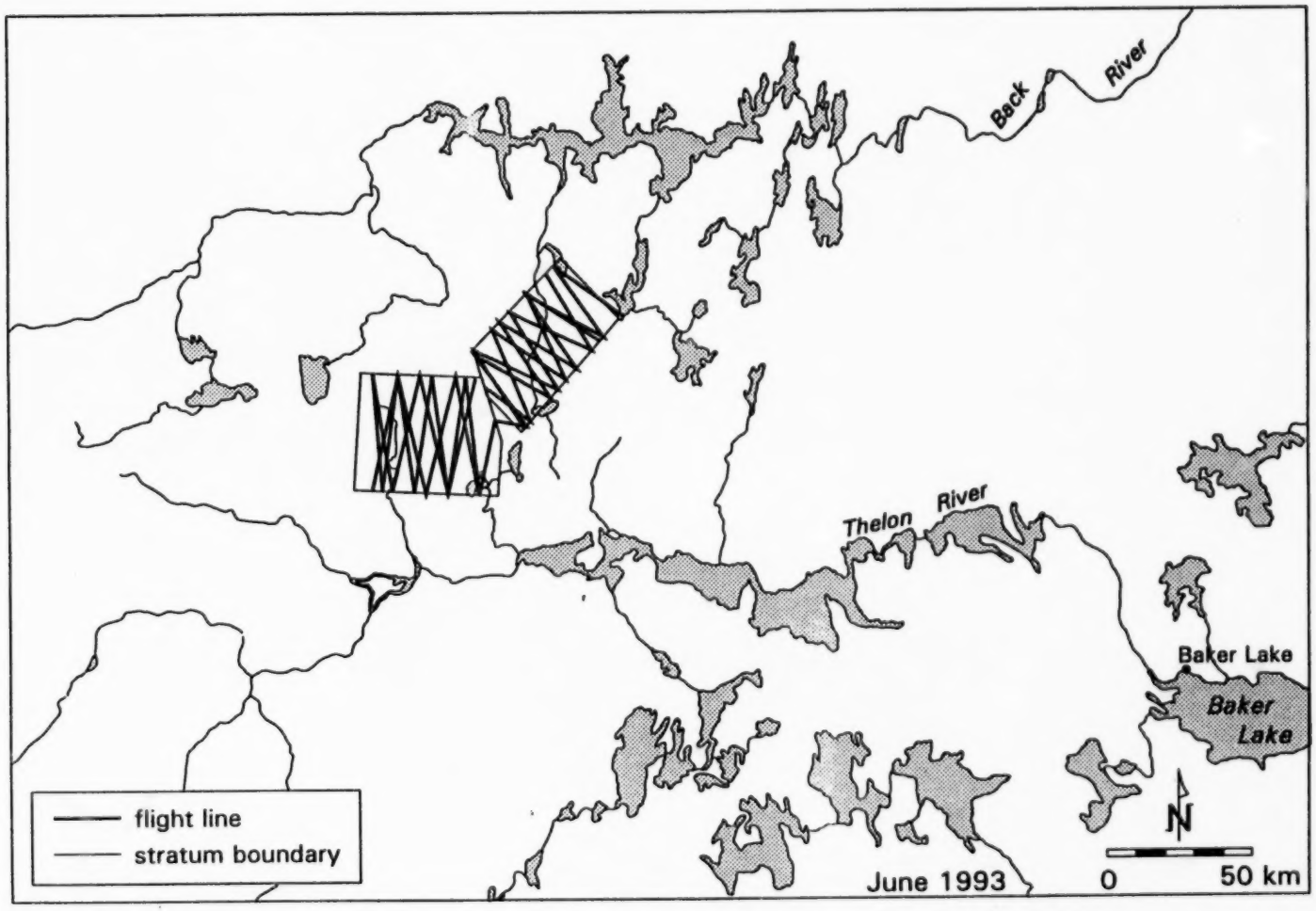

Figure 61. Beverly calving ground composition survey flight lines, 11-16 June 1993

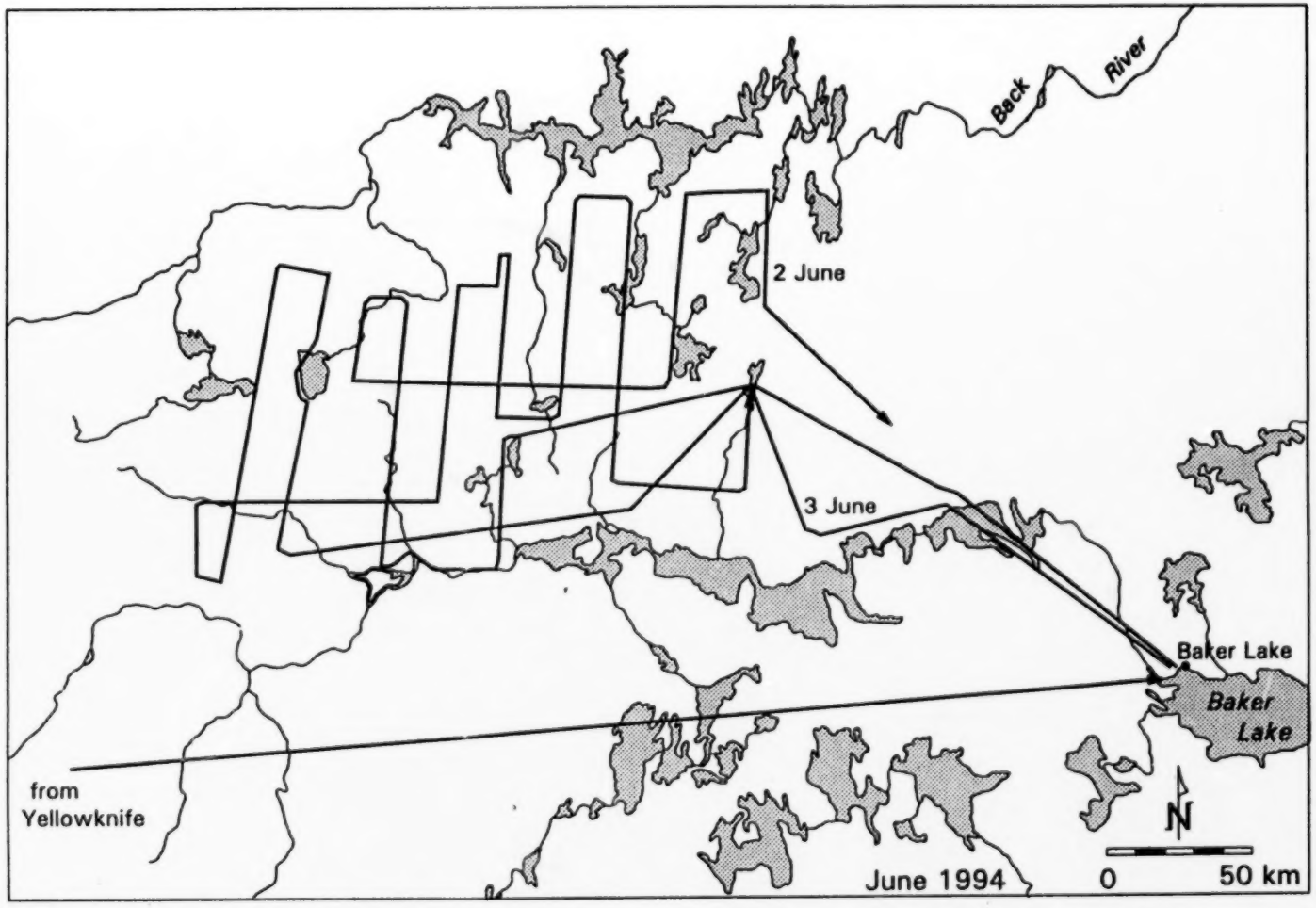

Figure 62. Beverly calving ground unsystematic reconnaissance flight lines, 2-3 June 1994

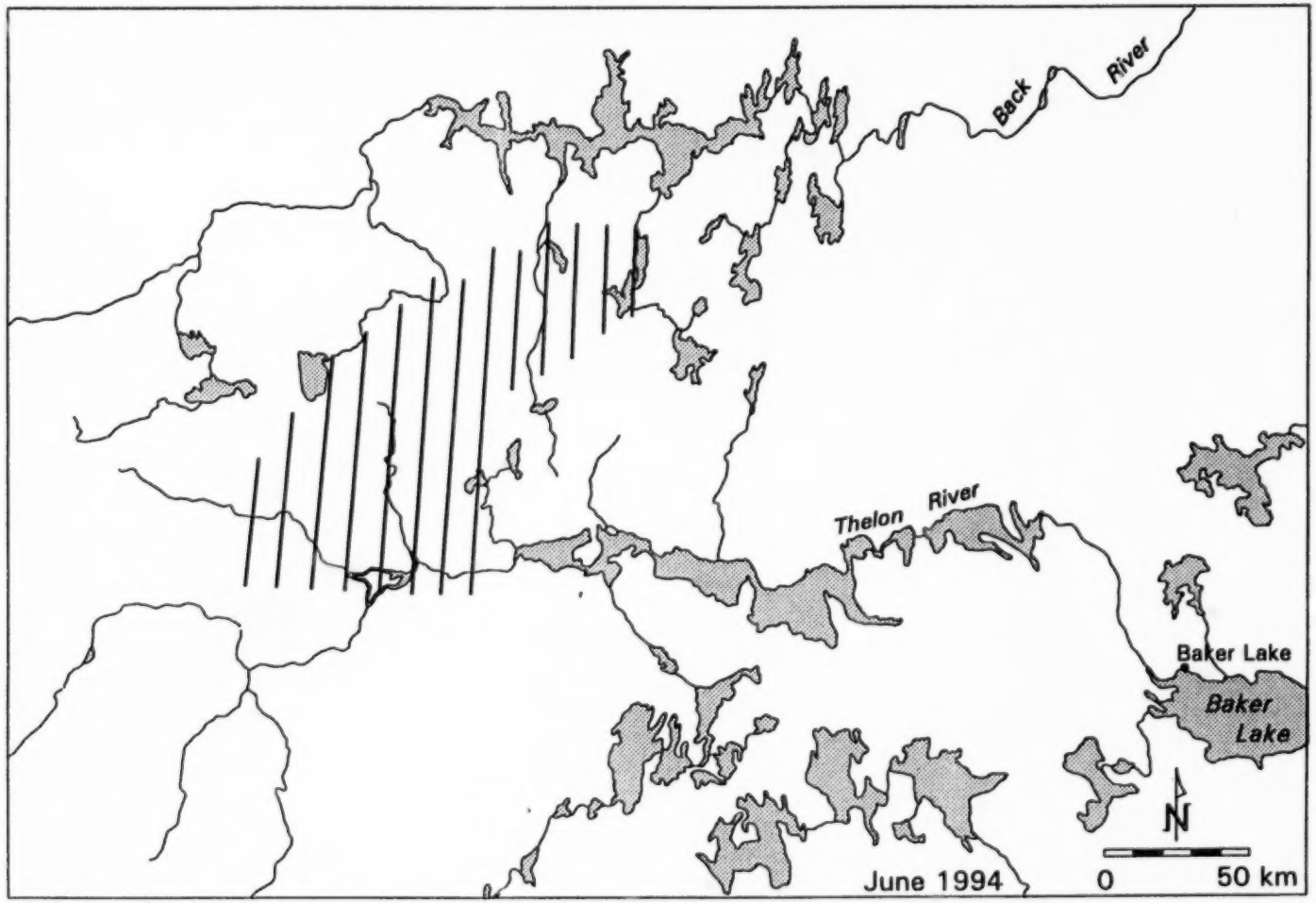

Figure 63. Beverly calving ground systematic reconnaissance flight lines, 4-5 June 1994

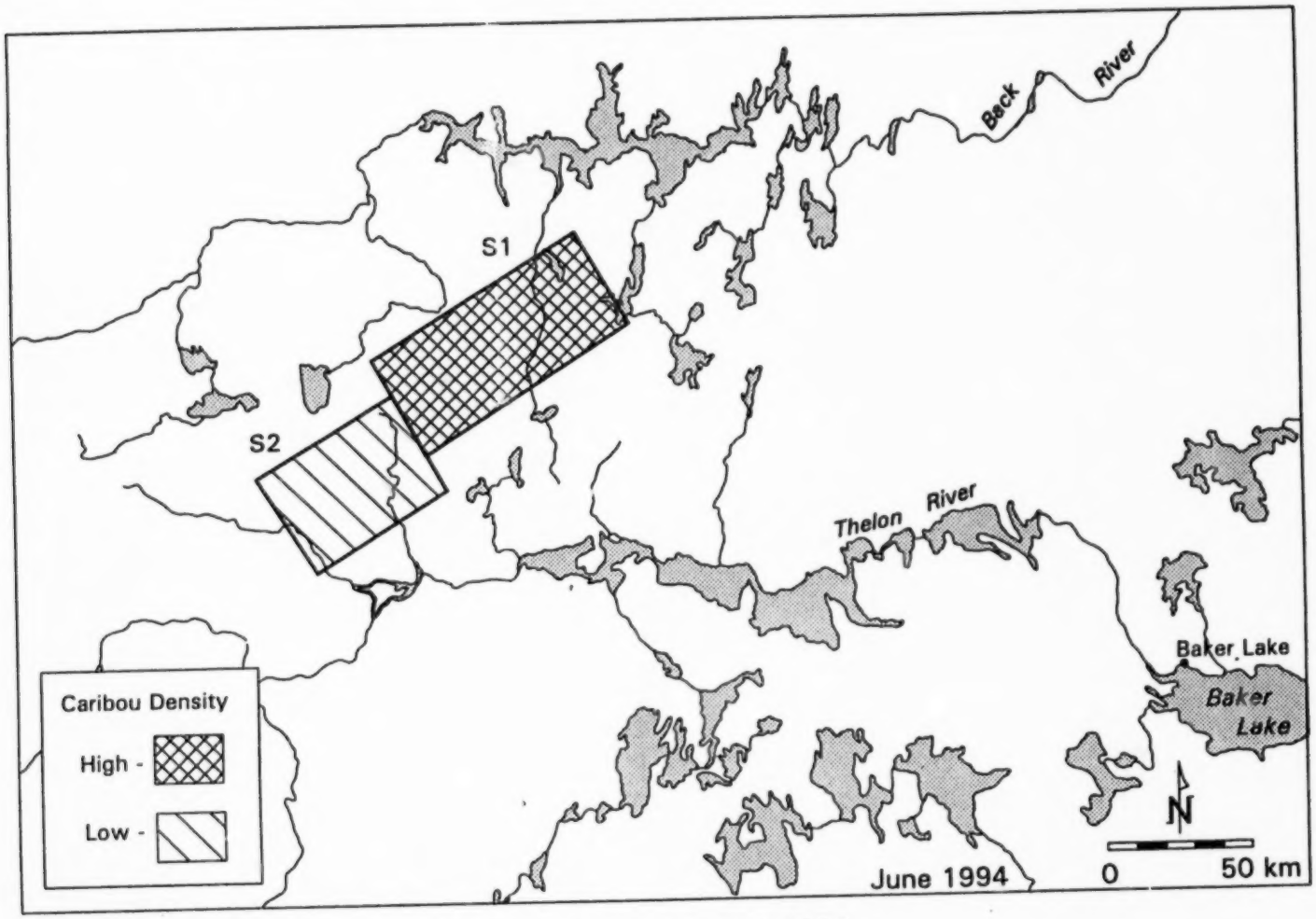

Figure 64. Beverly calving ground survey strata, 4-5 June 1994

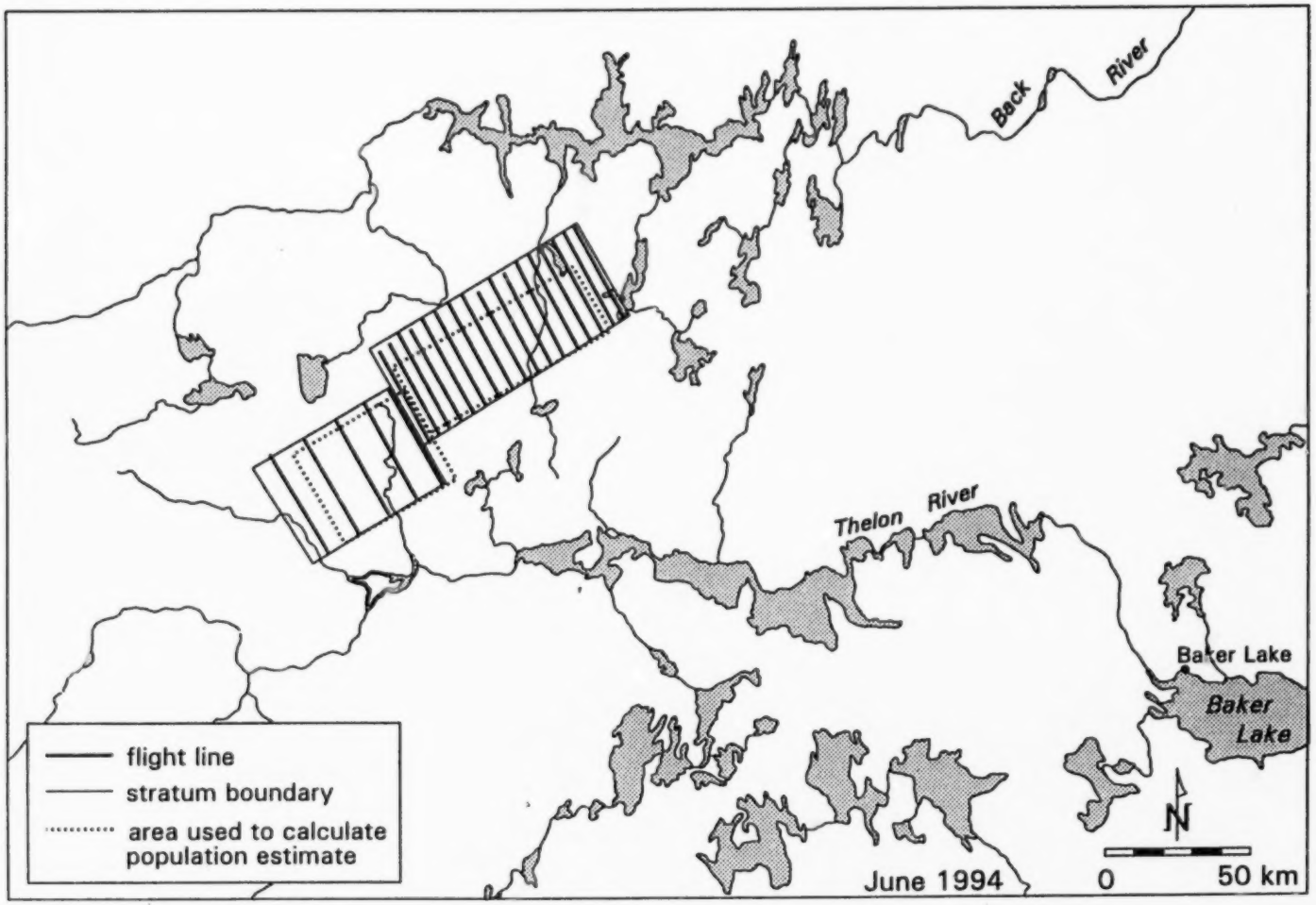

Figure 65. Beverly calving ground photographic survey flight lines, 7-8 June 1994

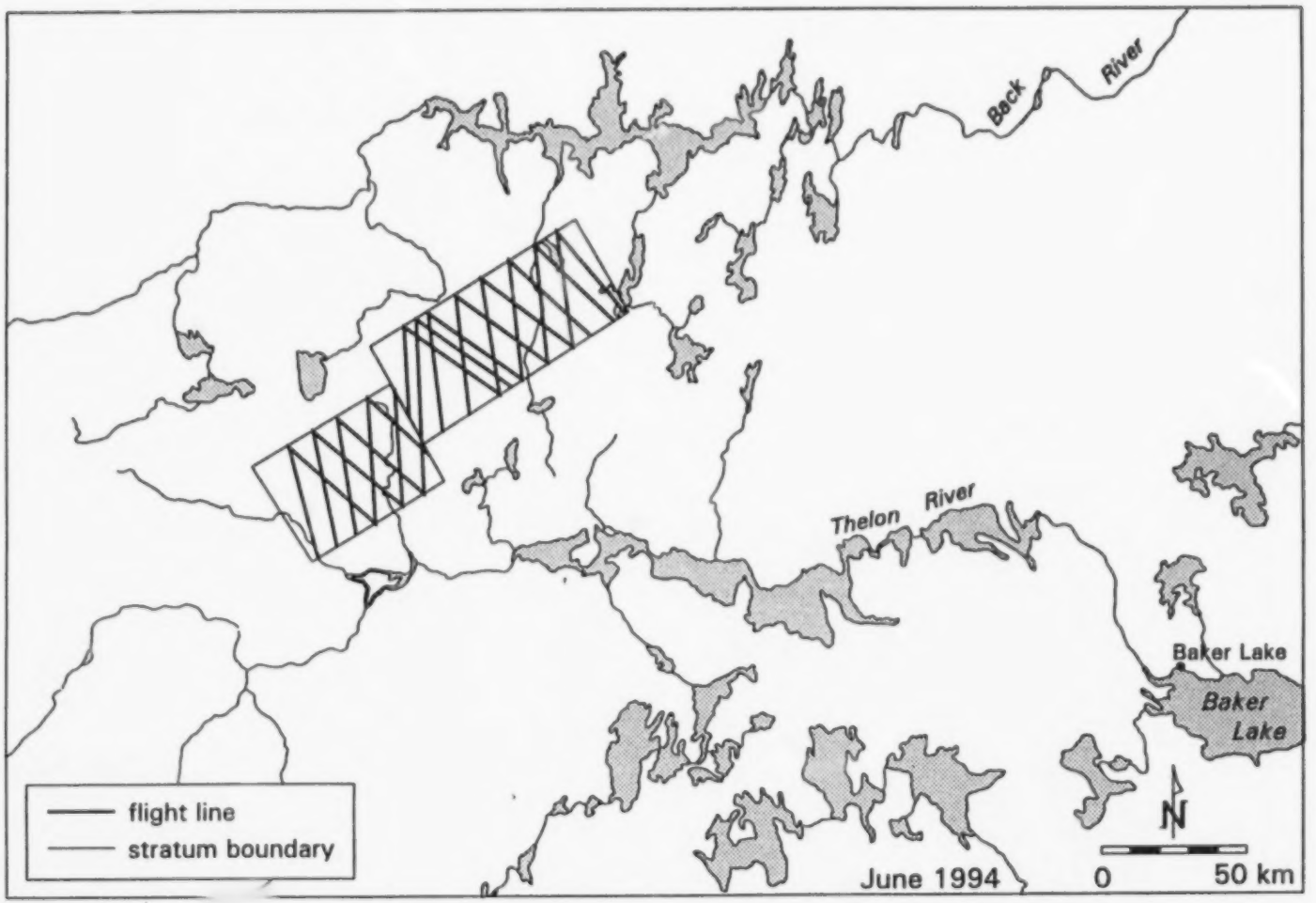

Figure 66. Beverly calving ground composition survey flight lines, 9-13 June 1994

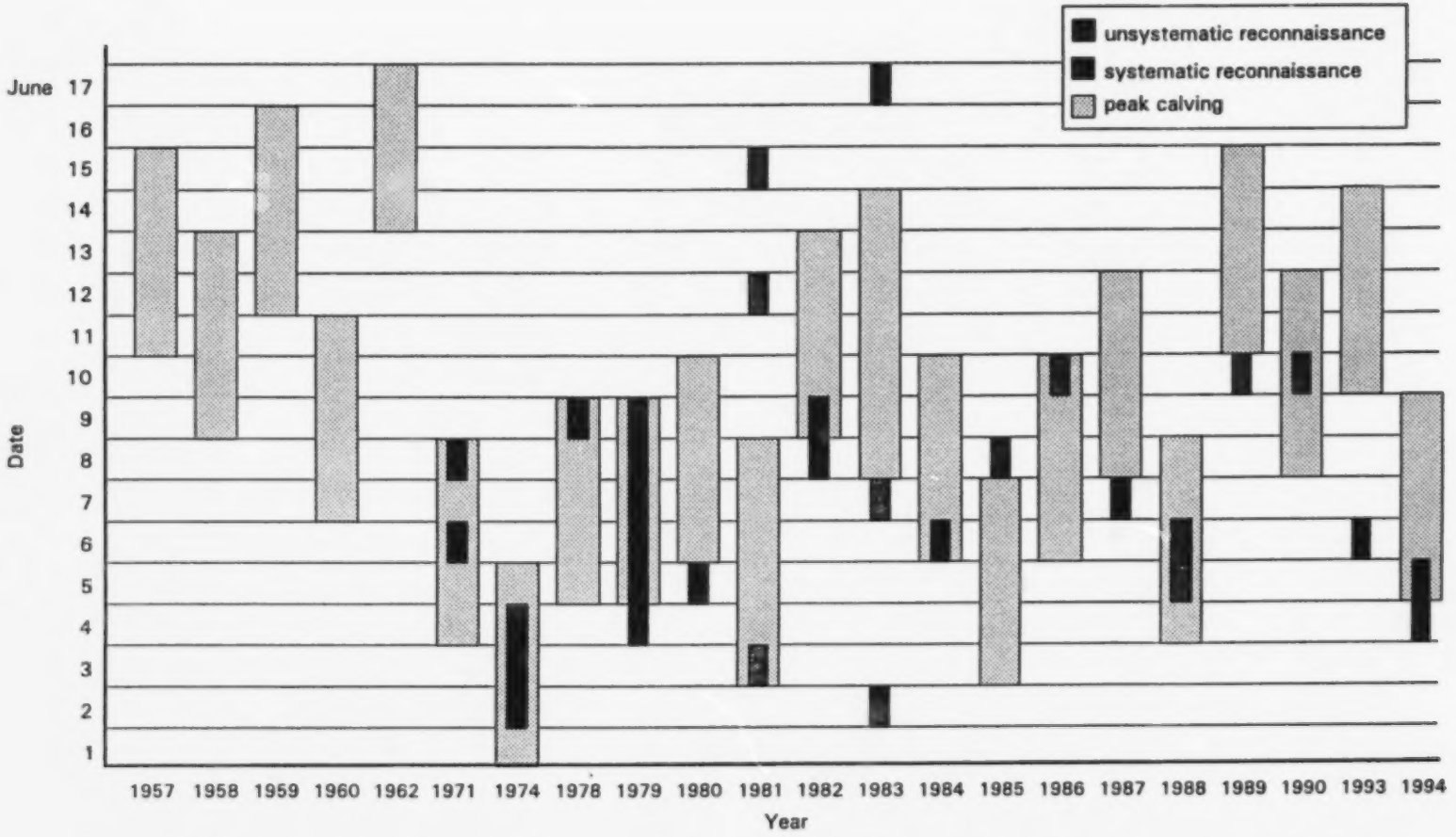

Figure 67. Peak calving dates (approximate) and dates of reconnaissance flights used to delineate the Beverly calving grounds, 1957-1994

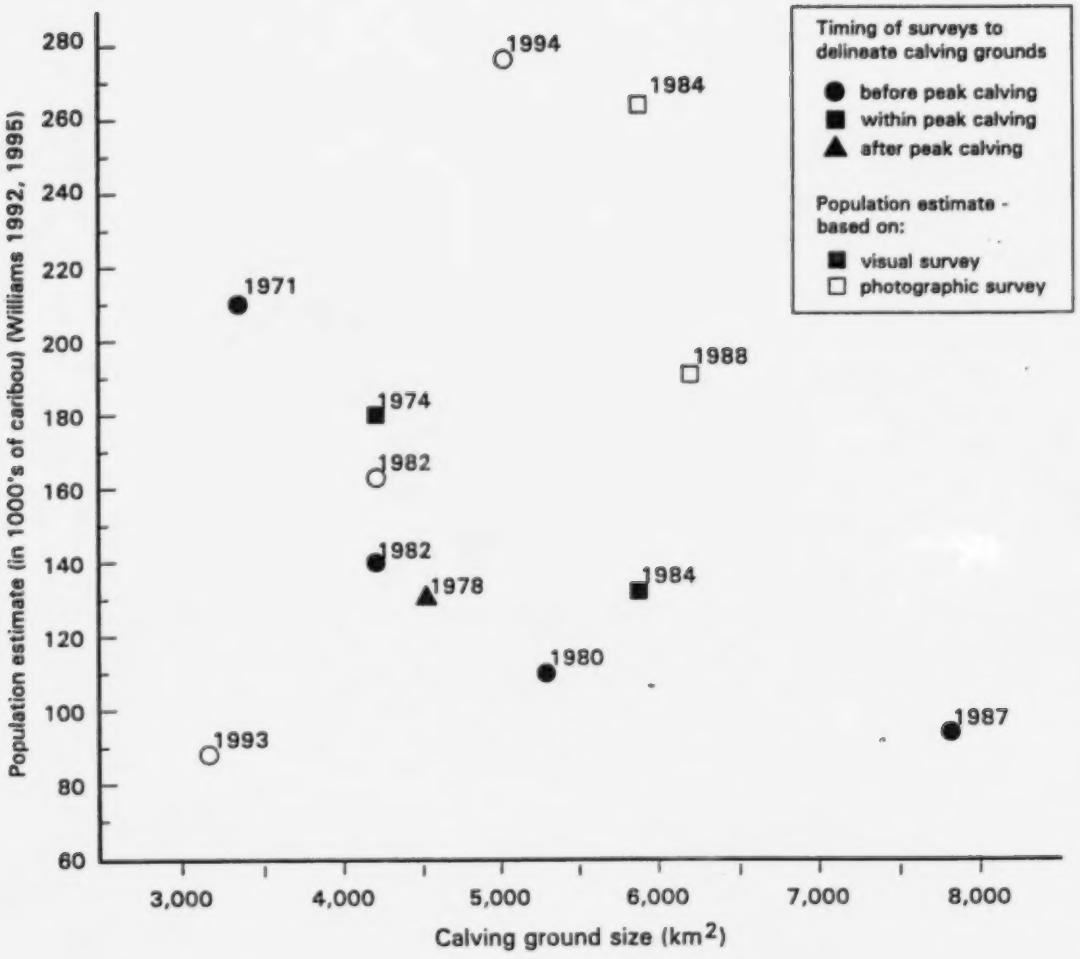

Figure 68. Calving ground size in relation to population estimate for the Beverly caribou herd and timing of surveys, 1971 - 1994. In 1971 and 1974, criteria for calving ground delineation differed slightly from remaining years.

RECOMMENDATIONS

1. As a result of the termination of the Caribou Monitoring Program in 1990, there are major gaps in our understanding of where Beverly caribou have been calving. Although RWED collected distribution information during census work in 1993 and 1994, nothing was documented for 1991, 1992, 1995, or 1996. Given the importance of calving habitat to Beverly caribou and the potential impact of industrial development, a long-term strategy for calving ground protection is required.

2. To systematically ensure that no calving areas are missed, reconnaissance flights should cover the entire traditional calving grounds.

3. Traditional knowledge of the use of the Beverly Lake area by calving caribou should be compiled.

ACKNOWLEDGEMENTS

We thank Mark Williams (BC Environment) and Robert Mulders (Regional Biologist, Keewatin) for their reviews of the draft report.

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APPENDIX A. Caribou densities in each stratum of the transect and photographic surveys on the Beverly calving grounds from 1978 to 1994.

	Stratified Transect Survey			Photographic Survey			
Year	High Density caribou/km² (stratum)	Medium Density caribou/km² (stratum)	Low Density caribou/km² (stratum)	High Density caribou/km² (stratum)	Medium Density caribou/km² (stratum)	Low Density caribou/km² (stratum)	Source/ Comments
1978	23.8 (I)	17.6 (III)	4.0 (IV)	–	–	–	Heard and Decker 1980
1979	32.1	4.0	0.1	–	–	–	Based on 1978 census estimate (Darby 1980)
1980	16.2 (I)	–	2.31 (II)	–	–	–	Gunn and Decker 1982
1982	18.5 (II)	13.6 (III)	6.7 (I)	45.7 (1)	13.5 (2)	3.7 (3) 6.3 (4) 11.8 (5) 3.7 (6)	Stephenson et al 1984, RWED files
1984	22.09 (1)	–	6.32 (2) 1.90 (3) 0.36 (4) 3.87 (5)	41.4	–	–	Gates 1984, RWED files
1987	9.27 (1)	6.97 (2) 4.69 (3) 1.46 (4)	–	–	–	–	Heard et al. 1990
1988	–	–	–	29.27 (1)	16.11 (2)	5.06 (3)	Heard and Jackson 1990
1993	–	–	–	20.65 (1)	12.97 (2)	–	Williams 1995
1994	–	–	–	71.02 (1)	13.41 (2)	–	Williams 1995

APPENDIX B. Calculation of peak calving dates for the Beverly caribou herd, 1957 to 1994.

Peak calving dates were taken from reports when available, and when not, dates were estimated according to the following assumptions:

> "Within the calving period, most cows calve during a 5-7 day peak. In the central and eastern Arctic, the calving period is approximately 31 May - 15 June with peak occurring around 4-10 June." (Fleck and Gunn 1982)
>
> May 25 to June 25 is the calving period for the Beverly and Qamanirjuaq herds (Gunn 1984).
>
> "If calving occurred as in the Kaminuriak herd in 1977, where there were 20% calves in herd 1-2 days before the peak...(the day when most calves are born ~45% calves)." (Heard 1980)
>
> "Peak calving is defined as the point at which one half of the breeding females have given birth." (Williams 1994)

$$\frac{\text{(\#cows with calves + \#antlerless cows with udder but no calf)}}{\text{(total \#breeding females)}}$$

1957 31 May - 1st calf seen (Kelsall 1957)
"Between June 11 and 17, the caribou continued to move strongly, although calving was actually taking place." (Kelsall 1957)

9-14 June (Loughrey 1957) from Kelsall 1968

"In 1957 and 1962, the peak of calving was late: 14-17 June". (Fleck and Gunn 1982)

PEAK ~11-15 June

1958 1 June - 1st calf seen (de Vos 1960)
1-12 June - most births; quickly drops off after the 12th (de Vos 1960)
- therefore peak is estimated at 12 June (de Vos 1960)

13- June (de Vos 1958) from Kelsall 1968

PEAK 9-13 June

1959 "The birth of calves covered the first three weeks of June with highest occurrence about June 14. It was estimated that 80% of calves were born during the period June 12-16." (McEwen 1959)

1 June - 1st record of newborn calf
21 June - last record of newborn calf
"During this period, the rate of calving was determined by aerial counts of the number of calves and the number of other animals." (McEwen 1959)

PEAK 12-16 June

1960 4 June - first calf observed (McEwen 1960)
10-11 June - peak of calving based on ratio of calves to total animals, excluding yearlings (McEwen 1960)
"87% of calving was completed during the period of June 7 to 11." (McEwen 1960)

PEAK 7-11 June

1962 "In 1957 and 1962, the peak of calving was late: 14-17 June". (Fleck and Gunn 1982)

PEAK 14-17 June

1965 Peak unknown. Report was not available.

1971 5 June - "...apparent that there were two main calving groups and that calving was well advanced." (Rippin 1971)

PEAK ~4-8 June

1974 late May - most of females already on calving ground (Moshenko 1974)
2 June (N) - 50% calves had dropped by this time (Moshenko 1974)
3 June (S) - 0% calves had dropped - appeared to be predominantly non-breeding animals (Moshenko 1974)

PEAK 1-5 June

1978 5-9 June with peak on the 7th (Heard and Decker 1980)
4-11 June (Darby 1978)

PEAK 5-9 June

1979 "...migrating cows were late moving northward..." (Darby 1980)
cows calving between 4-9 June but many hadn't reached calving grounds (Darby 1980)
"Most cows crossed the Thelon River at or near Lookout Point between 24 May and 9 June." (Darby 1980)
"Snowcover on the calving grounds near Sand Lake was estimated to be 80-100% in the first week of June." (Darby 1980)

PEAK ~5-9 June

1980 spring early; cows ~10 days ahead of average spring migration (Gunn and Decker 1982)

2 June - first saw newborn calves on SW edge of calving ground (Gunn and Decker 1982)
8 June - "Our impressions and the fact that dispersal appeared to be maximal on about 8 June, suggested the peak of calving was about 8 June." (Gunn and Decker 1982)

6-13 June (Cooper 1981)

PEAK 6-10 June

1981 2-5 June - early calving (Jingfors et al. 1982)
6-9 June - late calving (Jingfors et al. 1982)
11 June - start of post-calving period (Jingfors et al. 1982)

"In the Deep Rose Lake and Sand Lake area, calving peaked between 3-8 June." (Clement 1982)

PEAK 3-8 June

1982 5 June - few calves evident (Stephenson et al. 1984)
8 June - calves quite evident (Stephenson et al. 1984)
11,12 June - majority of cows had calves with them (Stephenson et al. 1984)

9-10 June - (H-central) calf:cow = 56/100
11-12 June - (L-E) calf:cow = 56/100 (Stephenson et al. 1984)
therefore peak in combined strata was between 10-13 June (Stephenson et al. 1984)

"Calving in the central portion of the Beverly caribou calving ground peaked on 10 June and was almost completed by 13 June." (Clement 1983)

9-12 June (Gunn 1984)

PEAK 9-13 June

1983 8-14 June (Miller et al. 1988)
17 June - "A large number of calves were seen on this flight and cows had started to aggregate into large herds of up to several thousand caribou in the eastern half of the calving area." (Bradley and Gates 1984)

PEAK 8-14 June

1984 30 May - large number of cows were seen between Sand Lake and the Garry Lakes, moving to E and SE (Bradley 1985)
6-12 June - Beverly cows were distributed over the calving grounds (Bradley 1985)
12 June - starting to form post-calving aggregations (Bradley 1985)

PEAK 6-10 June

1985 8 June - 85% of cows were with calves (Duquette 1985)

PEAK ~3-7 June

1986 10 June - 75% of cows were with calves (Liepins 1986)

PEAK ~6-10 June

1987 peak of calving (when ½ of the calves have been born) was relatively late in 1987 (Heard et al. 1990)

10 June - in S1,2,4 about half calves were born by 10 June (Heard et al. 1990)
- in S3 peak of calving not yet reached (Heard et al. 1990)
peak usually occurs by 7 June (Heard et al. 1990)

"Peak calving occurred between 9 and 10 June." (Ogilvie 1987)

PEAK 8-12 June

1988 most in high density stratum had given birth by 8 June (Heard and Jackson 1990, Williams 1995)

% calves on calving grounds:
8 June - 43% (composition)
9 June - 40% "
10 June - 41% "

% breeding females that have given birth:
8 June - 82% (composition)
9 June - 65% "
10 June - 81% "

PEAK 4-8 June

1989 10 June - small number of calves seen
- caribou still migrating to core calving area (Chalmers 1989)

PEAK ~11-15 June

1990 10 June - 50% of cows were with calves (Gauthier and Mulders 1990)

PEAK 8-12 June

1993 12 June - (S1-E) - 61% breeding females post-partum
- therefore in S1, peak occurred before 12 June (Williams 1995)

13 June - (S2-W) - 46% breeding females post-partum
15 June - (S2) - 60% breeding females post-partum
- therefore in S2, peak occurred on 14 June (Williams 1995)

PEAK 10-14 June

1994 9 June - (S1-E) - 82% breeding females post-partum
(S2-W) - 65% breeding females post-partum
- therefore peak of calving occurred before 9 June (Williams 1995)

PEAK 4-8 June

APPENDIX C. Tables containing strata and transect areas (km^2) for the Beverly calving grounds, 1971-1994.

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Table C1. Survey and transect areas, Beverly calving grounds, 1971 and 1974

Year	Type of Survey	Survey area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
1971	random block	1636 (N)	276 (N)	16.9	Rippin 1971
		1728 (S)	276 (S)	16.0	
		3364 (total)	552 (total)	16.4	
1974	random block	3318 (N)	655 (N)	19.7	Moshenko 1974
		901 (S)	328 (S)	36.4	
		4219 (total)	983 (total)	23.3	
	strip	3318 (N)	415 (N)	12.5	
		901 (S)	113 (S)	12.5	
		4219 (total)	528 (total)	12.5	

Table C2. Strata and transect areas, Beverly calving ground, June 1978

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Stratified transect	I	1193	422.6	35.4	Heard and Decker 1980
	II	1458	182.3	12.5	Stratum II areas were taken from DDR files.
	III	1222	600.5	49.1	
	IV	660	98.8	15.0	
Total		**4533**	**1304.2**	**28.80**	

Table C3. Strata and transect areas, Beverly calving ground, June 1980

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Stratified transect	I	2480	957.6	38.6	Gunn and Decker 1982
	II	2808	301.6	10.7	
Total		**5288**	**1259.2**	**23.8**	

Table C4. Strata and transect areas, Beverly calving ground, June 1982

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Stratified transect	I	1508	240.2	15.9	Stephenson et al 1984
	II	1771	826.6	46.7	
	III	940	378.4	40.3	
Total		**4219**	**1445.2**	**34.3**	
Photo-graphic	H (1)	704	186.2	26.4	RWED files
	M (2)	769	181.5	23.6	
	LS (3)	383	97.9	25.6	
	LW (4)	657	164.9	25.1	
	LE (5)	474	106.9	22.6	
	VL (6)	509	116.5	22.9	
Total		**3496**	**853.9**	**24.4**	

Table C5. Strata and transect areas, Beverly calving ground, June 1984

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Stratified transect	1	2134	–	–	Gates 1984
	2	800	–	–	
	3	1394	–	–	
	4	946	–	–	
	5	615	–	–	
Total		**5889**	–	–	
Photo-graphic		3503	723.5	20.7	RWED files
Total		**3503**	**723.5**	**20.7**	

Table C6. Strata and transect areas, Beverly calving ground, June 1987

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Stratified transect	1	2582	1134	43.9	Heard et al. 1990
	2	2056	442	21.5	
	3	1918	234	12.2	Heard and Jackson 1990
	4	1272	215.6	17.0	
Total		**7828**	**2025.6**	**25.9**	

Table C7. Strata and transect areas, Beverly calving ground, June 1988

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Photo-graphic	1	2228	372.6	16.7	Heard and Jackson 1990
	2	2005	186.5	9.3	
	3	1950	135.7	7.0	
Total		**6183**	**694.8**	**11.2**	

Table C8. Strata and transect areas, Beverly calving ground, June 1993

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Photo-graphic	1	1439	305	21.2	Williams 1995 RWED files
	2	1757	469.2	26.7	
Total		**3196**	**774.2**	**24.2**	

Table C9. Strata and transect areas, Beverly calving ground, June 1994

Type of Survey	Stratum	Stratum area (km^2)	Transect area (km^2)	% Coverage	Source/ Comments
Photo-graphic	1	3103 [1855]	714.5 [342.2]	23.0 [18.4]	Williams 1995, RWED files. Areas in square brackets were used to calculate the population estimate.
	2	1908 [1438]	195.7 [140.8]	10.3 [9.8]	
Total		**5011 [3293]**	**910.2 [483.0]**	**18.2 [15.7]**	

APPENDIX D. Beverly Caribou Protection Area Maps, 1978 - 1990.

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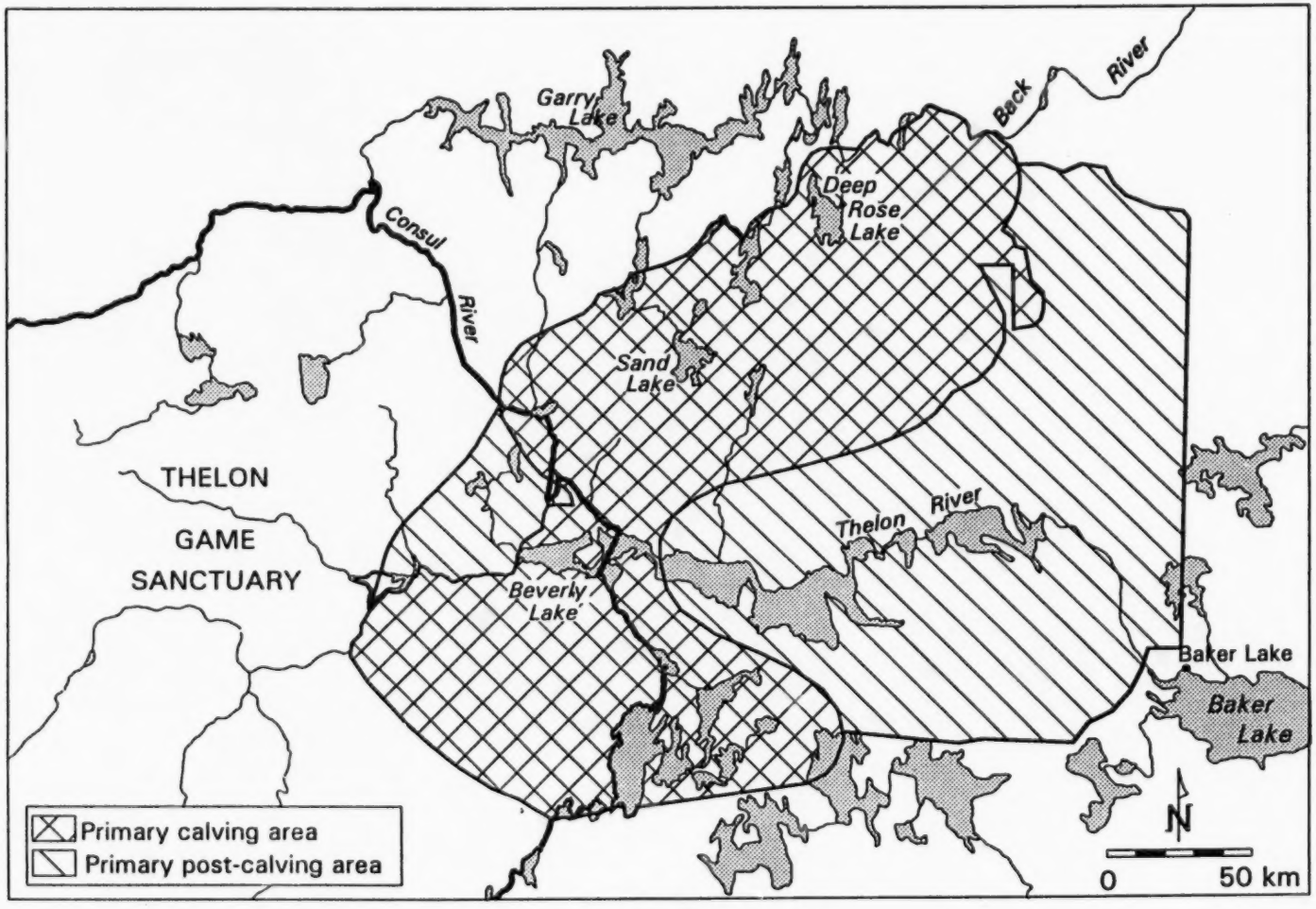

Figure D1. Beverly Caribou Protection Map 1978 (Darby 1978).

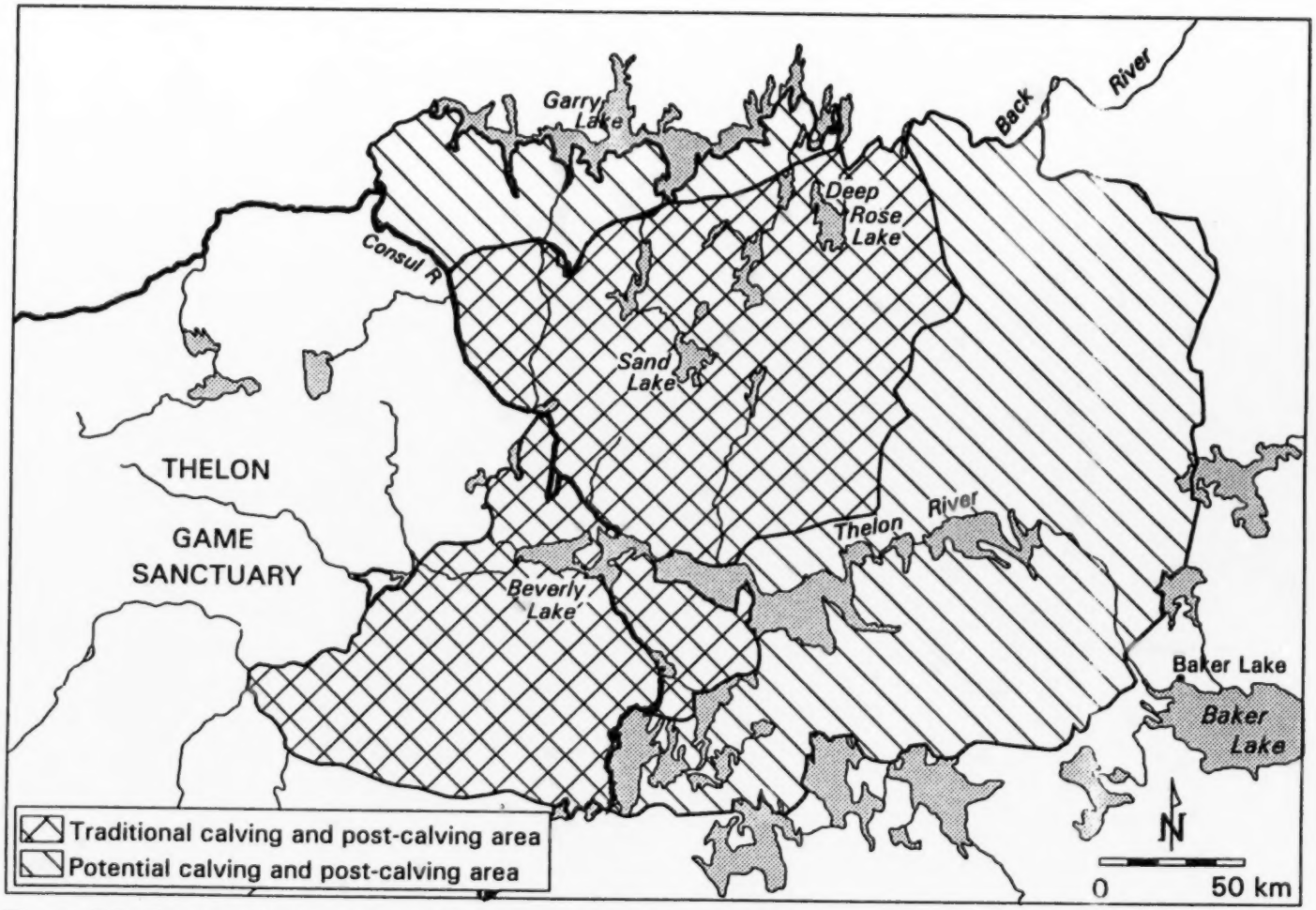

Figure D2. Beverly Caribou Protection Map 1979 (Darby 1980).

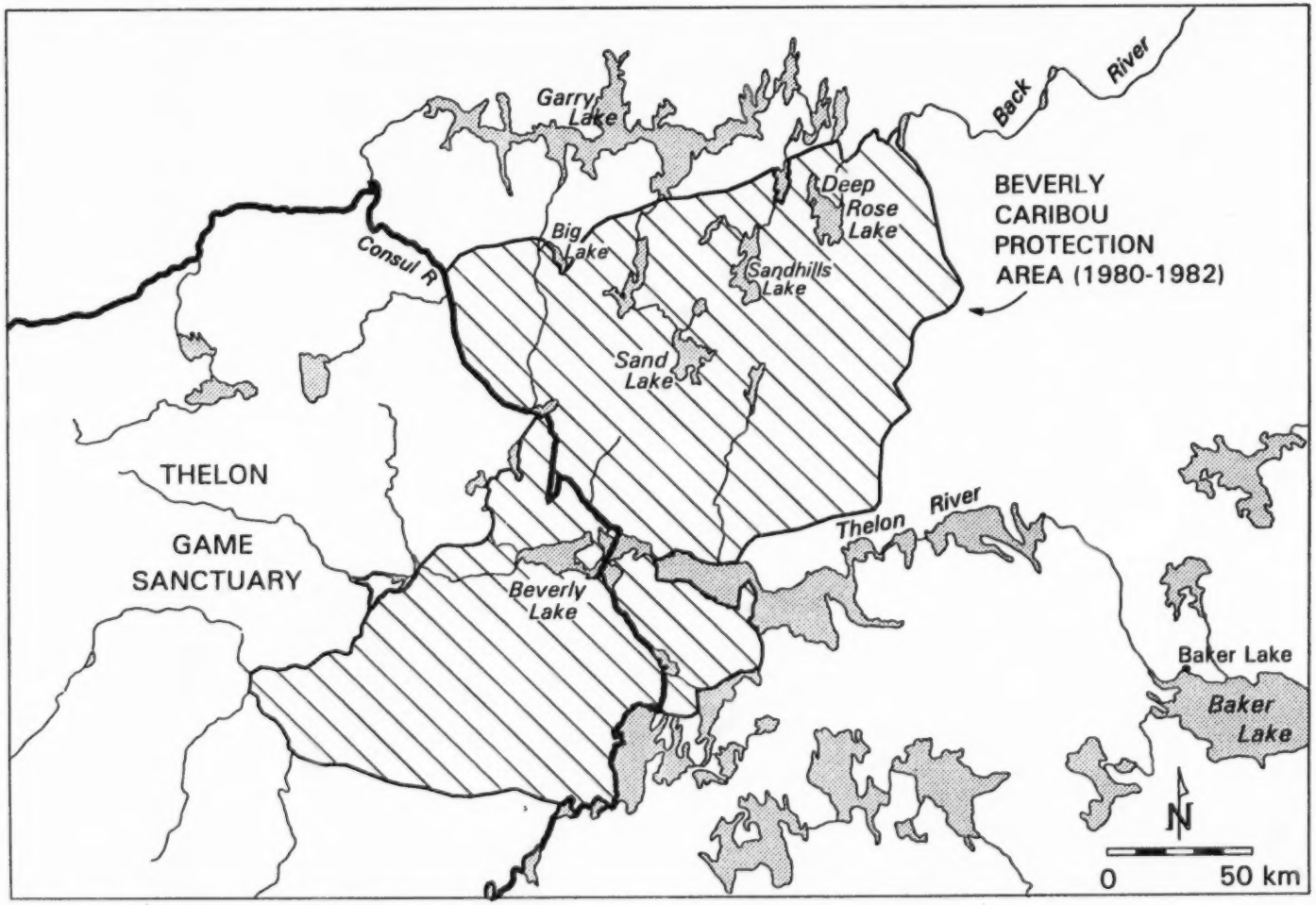

Figure D3. Beverly Caribou Protection Area, 1980-1982 (Cooper 1981, Clement 1982, Clement 1983)

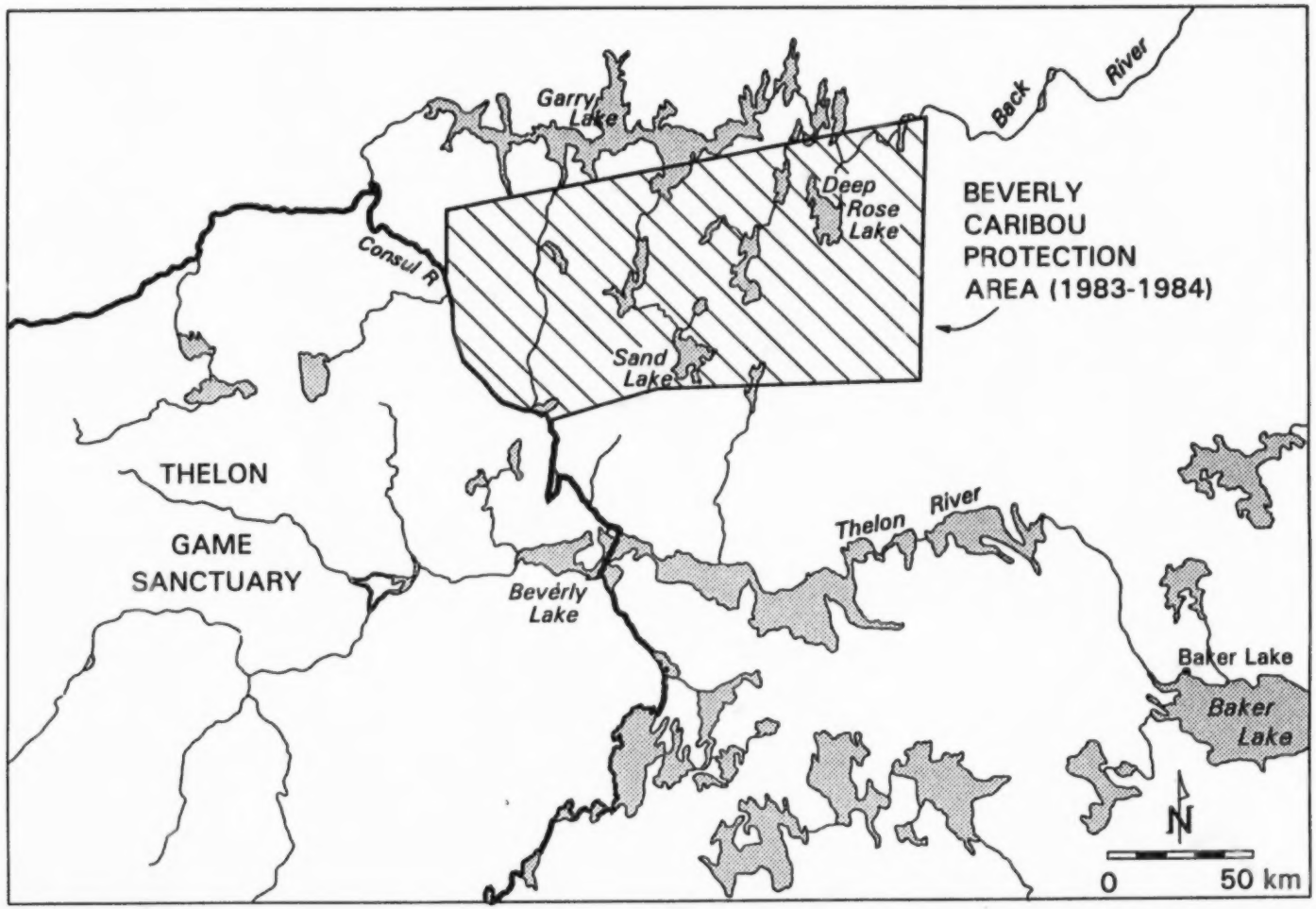

Figure D4. Beverly Caribou Protection Area, 1983 and 1984 (Bradley and Gates 1984, Bradley 1985)

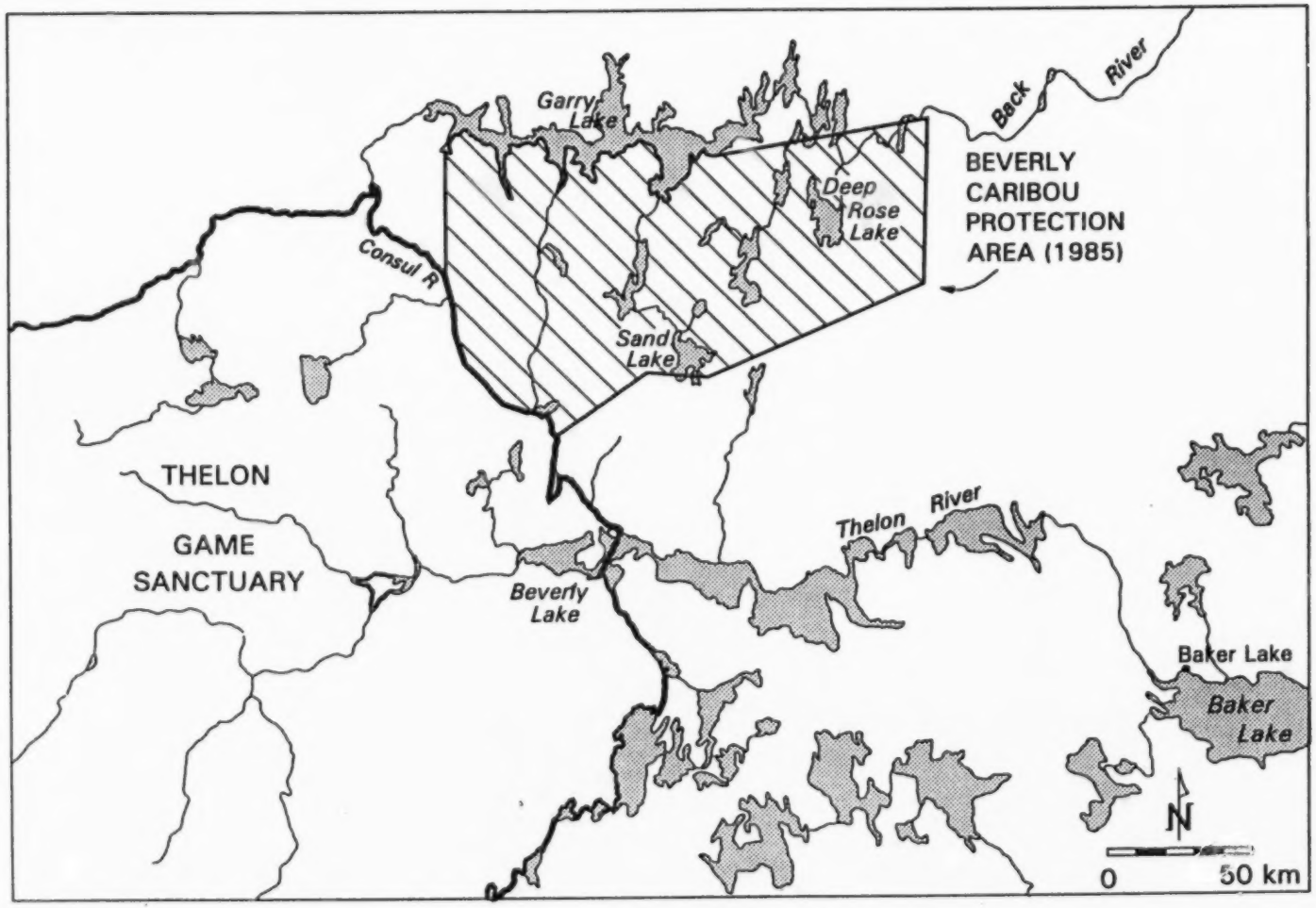

Figure D5. Beverly Caribou Protection Area, 1985 (Duquette 1985)

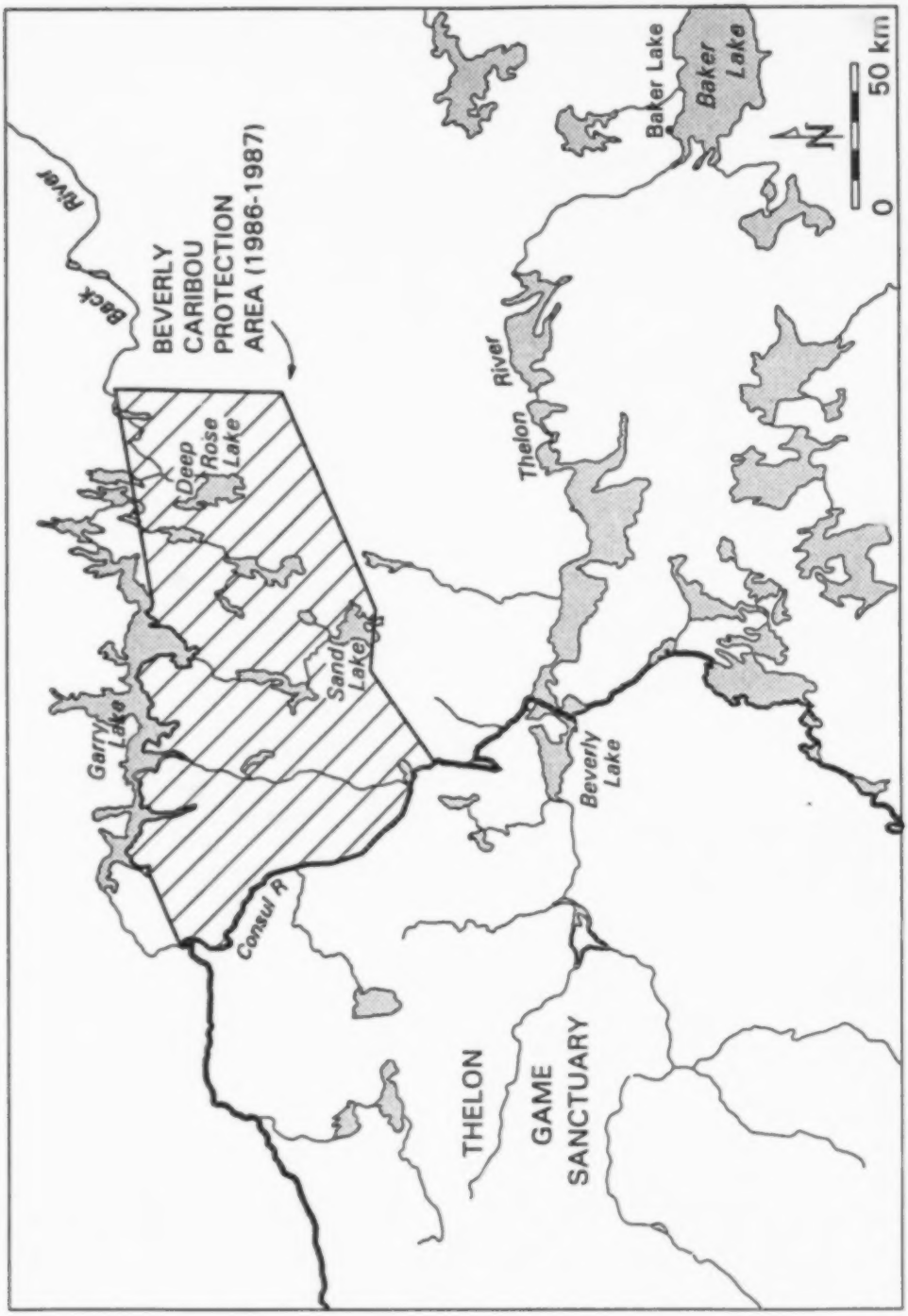

Figure D6. Beverly Caribou Protection Area, 1986 and 1987 (Liepins 1986, Ogilvie 1987)

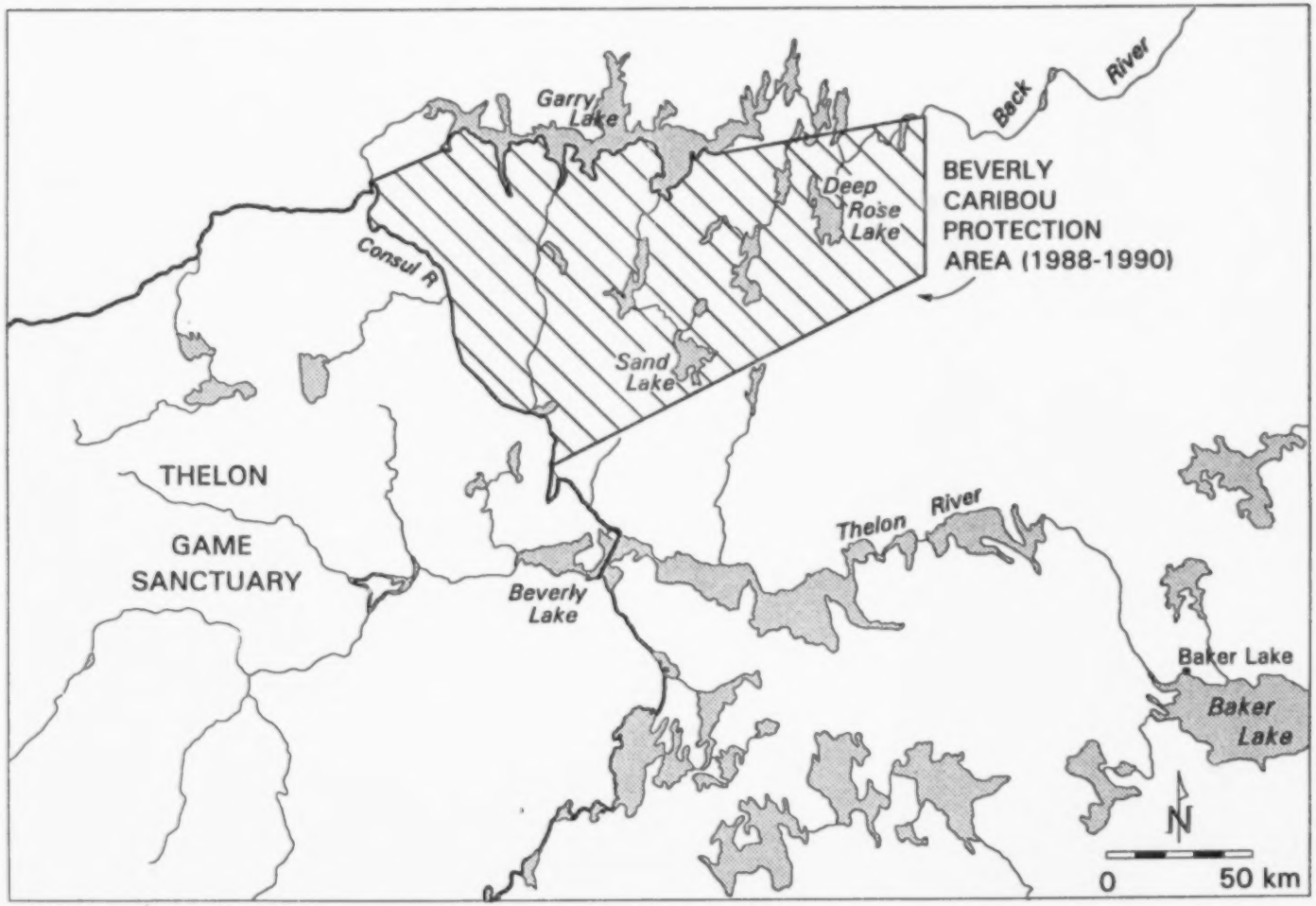

Figure D7. Beverly Caribou Protection Area, 1988-1990 (Ogilvie 1989, Chalmers 1989, Gauthier and Mulders 1990)